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## EXPERIMENTAL RESEARCHES UPON VASOMOTRICITY<sup>1</sup>

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THE facts which we have observed during the past few years, thanks to the surgery of the sympathetic system, seem to us incompatible with the classical ideas on the mechanism of vasomotor actions. They are precise facts, graphically registered, which anyone will be able to reproduce if he puts himself under the same conditions as we did. They seem to imply a revision of the actual theories on vasomotricity. One will judge.

### FIRST GROUP OF FACTS

I. If one removes, in man, the totality or almost the totality of the cervical sympathetic chain, one observes, at the level of the superior limb, after a very short phasis of increase in the arterial tension, a marked lowering of the pressure (5 cm. of Hg.), bearing on the maxima and on the minima. Then, after a few weeks, the arterial tension reaches again its preceding value and maintains it, usually a little below the pre-operative rate.

The modifications are bilateral; their evolutions are parallel and simultaneous on both sides. Sometimes they reach the four limbs where one observes everywhere and at the same time the same variations as previously indicated.

Then, after a few weeks, it becomes impossible to put in evidence the least vasomotor sign of a sympathetic neurotomy. There remains not a single trace of vasomotor paralysis. But, on the operated side, the reactions to external conditions do not take place any more (reactions to hot and cold baths by immersion of the hand belonging to the operated side).

Here is an example of it:

A man is submitted to the entire removal of the cervical chain down to the stellate ganglion (exclusively). One adds to this removal the section of all the rami coming from the stellate ganglion (C<sup>6</sup>, C<sup>7</sup>, C<sup>8</sup>, D<sup>1</sup>) and of the roots of the vertebral nerve. Before the operation, one had noted:

	On the right side	On the left side
Mx. ....	18	19
Mn. ....	9	6
Index .....	4.5	4

<sup>1</sup> Translated by Jean Verbrugge-Anvers.

and eight months later, one finds:

	On the right side	On the left side
Mx. ....	19	19
Mn. ....	10	10
Index ....	4.5	4.5

2. The resection of the stellate ganglion, which means practically the suppression of all the vasomotors of the upper extremity, has the same effects; the modifications are bilateral. After a few weeks, there is also a return to the preceding value and stabilization at that level.

Here is an example of it:

Mrs. L. is submitted, for asthma, to an extirpation of the right stellate ganglion. The day previous to the operation, the blood pressure had been:

	On the right side	On the left side
Mx. ....	13	13
Mn. ....	9	9
Index ....	3	3

21 months later, we find:

	On the right side	On the left side
Mx. ....	13½	13½
Mn. ....	9	9
Index ....	3½	2½

At the same time, the cutaneous temperature measures at the level of the pommels:

To the right .....	36.5°	To the left .....	36.5°
and the tonometer of Gärtner shows at the level of the middle-finger:			
On the right....	14 cm. of Hg.	On the left....	14 cm. of Hg.

3. The results are the same if one cuts all the rami belonging to the superior limb, from C2 to D1 inclusively, including or not the branches of origin of the vertebral nerve.<sup>2</sup>

Here is an example of it:

A woman undergoes the section of all the rami of the neck from C2 to D1 inclusively for angina pectoris. One notes before the operation the following values:

	On the right side	On the left side
Mx. ....	12	11
Mn. ....	9¾	8
Index ....	¾	1¼

One year afterwards, day for day, we find:

	On the right side	On the left side
Mx. ....	12	12
Mn. ....	7½	7.5
Index ....	1½	1¼

When the circulatory conditions are thus reestablished, generally speaking, the reactions of adaptation to heat and cold are once more normal. Only twice

<sup>2</sup> Leriche et Fontaine: Des modifications de la pression artérielle consécutives aux ramicotomies inférieures. Archives des maladies du coeur. Janvier, 1926, T. xix, p. 21.

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were they incomplete; there was question in both cases of patients having undergone, on both sides, a resection of the rami of the brachial plexus and a humeral sympathectomy, once for a Raynaud's disease and once for sclerodermy. The study of the blood pressure gave, in one of these cases, the following results:

Before intervention:

At rest:	On the right side	On the left side
Mx. ....	14	15
Mn. ....	5	6
Index ....	3	4

After a cold bath:	On the right side	On the left side
Mx. ....	11	11
Mn. ....	6	6
Index ....	2	2

17 months later:

At rest:	On the right side	On the left side
Mx. ....	12	13
Mn. ....	7	7
Index ....	3½	5½

After a cold bath:	On the right side	On the left side
Mx. ....	12	12
Mn. ....	7	7
Index ....	3	5

In the other case, it was almost identical. One conceives, however, very well that, after a particularly extensive neurotomy, one may easily lose the possibility of adaptation of the extremities to the external conditions.

4. Likewise, the cutting of the lumbar chain, between the second and third ganglion for example, the section of all the lumbar rami are followed by an active vasodilatation which lasts from three to four weeks and ceases by and by, allowing the normal conditions to reappear gradually. Here again, the modifications are parallel in their evolution and take place bilaterally.

5. In man, we have not resected the whole lumbar chain, but we have noted that the extirpation of a single ganglion has the same effects as ramisection. In the dog, two months after the unilateral extirpation of the lumbar sympathetic system (ganglions L<sub>2</sub>, L<sub>3</sub> and L<sub>4</sub>), blood pressure simultaneously registered in both femoral arteries with two manometers of François Frank, is rigorously similar on the operated side and on the healthy one.<sup>8</sup> The vasomotor reactions produced by any of the usual procedure are the same on both sides as far as the sense of the reaction and its value are concerned.

<sup>8</sup>One knows, however, that Claude Bernard has noted in a dog, eighteen months after the extirpation of the superior cervical ganglion, a persistent vasodilatation with hyperthermy at the level of the paw. But one may have a persistent hyperthermia in cases where the pressure has come back to the normal.

In one case, we have seen, after a year, the temperature of the peripheric parts remain 4° below the temperature of the opposite side, while the pressure and the oscillometric index had come back to the normal.

*After all, the section of all the rami, said to be vasomotor, of a limb, never produces any durable trouble of vasomotricity and especially never does it bring about any vasomotor deficit.*

Here are some more facts which will help to testify in the same way:

6. The liberation of the median cervical chain, the extirpation of the median cervical ganglion, produce a marked pharyngeal and laryngeal active hyperæmia, strong enough to reach sometimes the stage of an cedematous exudation. It lasts three to four days, then disappears completely without leaving trace.<sup>4</sup>

7. Periarterial sympathectomy brings about all the signs of an active vasodilatation and in a few weeks, the vasomotor reactions come back to the usual rate.<sup>5</sup>

8. The resection of an obliterated arterial cord<sup>6</sup> provokes a vasodilatation acting in the same sense as in periarterial sympathectomy, with active local hyperæmia and hyperleucocytosis.<sup>7</sup> Vasodilatation is more persistent than after sympathectomy, but it always tends to come back to normal.

9. In certain rather particular cases (Buerger's disease) where one finds obliterated venous cords under the skin, the resection of one of these cords produces a momentaneous active vasodilatation of the same type as the arterial resection.

*After all, there is no sympathetic operation which would be followed by vasoparalytic phenomena. All those which we have been able to perform on men (and those which we have been able to perform experimentally on animals in a similar way) have been rapidly followed by an active temporary vasodilatation which does not remain localized to the downward territory, but usually extends to the limbs.*

After more than 300 sympathetic operations at all levels, we do not know yet at which level we should act in order to reach vasodilator nerves. Everything happens as if there were none, although, however, the vasodilator actions are constant. It does not seem that up to now these surprising observations have impressed the physiologists.

Another new fact which should be put forward is the bilaterality and even the generalization to the four limbs of vasomotor actions produced by any sympathetic section. This fact alone is sufficient to show the impossibility in which we are to continue admitting the classical theory, which pretends to see in peripheric sympathetic nerves, centrifugal nerves, going from the medulla to the vessels with ganglionar interruptions.

<sup>4</sup>Leriche et Fontaine: Faits chirurgicaux touchant l'innervation sympathique du larynx et du pharynx. La Presse Médicale, Septembre 22, 1926.

<sup>5</sup>Leriche et Heitz: Des effets physiologiques de la sympathectomie périphérique. C. R. de la Soc. Biologie, Févr. 20, 1917.

<sup>6</sup>Leriche et Heitz: De la réaction vasodilatatrice consécutive à la résection d'un segment artériel oblitéré. C. R. de la Société de Biologie, Février 3, 1917.

<sup>7</sup>Leriche et Fontaine: De l'influence des opérations sympathiques sur la leucocytose. La Presse Médicale, Sept. 4, 1926.



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### SECOND GROUP OF FACTS

The cutting of some sensory nerves produces the same phenomena of vasodilatation as the sympathetic operations.<sup>8</sup>

Refrigeration of mixed nerves has the same hyperæmic effects.<sup>9</sup>

The extirpation of neuromas of cicatrization of mixed nerves acts exactly in the same way.<sup>10</sup>

In all these conditions, one has only observed phenomena of active vasodilatation. Never have we seen any paralytic phenomena and never any vasoconstrictor phenomena. Likewise, the section of a mixed nerve, like the sciatic nerve in man, never abolishes the active vasomotricity. It does nothing else but disorder the local vasomotor reactions. Several months after the section, one is able to observe very marked hyperæmic crises with rise in temperature of several degrees above normal.

### THIRD GROUP OF FACTS

The section of the medulla which is supposed to produce paralytic vasodilatation, leaves unchanged the normal vasomotor reactions. We have seen, after an extensive destruction of the dorso-lumbar medulla (D8 to D10) all the vasomotor reactions persist at the level of the inferior limbs, at the end of three months. The pressure and the oscillations were subnormal (there was œdema present). An intravenous injection of a quarter of a milligram of adrenaline and in intradermic injection of a weak quantity of an extensive solution of adrenaline were followed by the usual reactions; the same result was obtained with hot and cold baths. A periarterial sympathectomy had been followed with the usual vasoconstrictive and vasodilator reactions, without the least quantitative variations.<sup>11</sup>

In dog, after section of the medulla, vasomotor reactions are not modified, even if one adds to the myelotomy an extirpation of the lumbar sympathetic chain or a section of the sciatic or both of them. Albert,<sup>12</sup> in his complete experimentation on vasomotor reflexes has always seen the traumatic vasomotor reflexes persist, even after section of the medulla, sciatic and crural nerves.

These facts seem to us incompatible with the existence of classical centri-

<sup>8</sup> de Nabias: Des résultats immédiats de la neurotomie sympathique simple dans les cas d'ulcères variqueux. XXXème Congrès français de Chirurgie, Octobre 5, 1921, p. 447.

<sup>9</sup> Laewen: Vereisung des Nervus Ischiadicus und des Nervus saphenu bei angiospastischen Schmerzzuständen der unteren Extremität. Münch. Med. Woch., 1922, T. lxix, No. 11, p. 389.

Laewen: Ueber Nervenvereisung bei angiospastischen Schmerzzustand. Zentralblatt für Chirurgie, Septembre 1, 1923, T. 1, No. 35, pp. 1346-1350.

<sup>10</sup> R. Leriche et R. Fontaine: Modifications vasculaires consécutives à l'ablation d'un névrôme du plexus brachial. Réunion neurologique de Strasbourg, Décembre, 1925, in Revue Neurologique, 1926.

<sup>11</sup> R. Leriche et R. Fontaine: Sur l'état de la vasomotricité après section de la moëlle. Soc. de neurol. de Strasbourg, 1926, vol. xl, p. 14.

<sup>12</sup> Albert: Etude exp. des troubles vaso-moteurs réflexes. Arch. Int. de physiol., Mai. 31, 1924, f. 4, T. xxii.

fugal vasomotor nerves, going from the medulla to the periphery, the ones being loaded with vasoconstrictive impulses, the others with vasodilator impressions. Our operations on the rami and on the lateral chains do not allow us to think that, if such are things, it is due to the fact that vasodilators get exhausted before reaching the periphery, as have said certain physiologists.

How could we explain this apparent disagreement between facts and theory?

One single hypothesis seems possible: One has to refer to the periphery the place of production of vasomotor actions which regulate the local circulations. One admits to-day the existence of vasomotor centres at the level of the arterial walls. One may suppose that, between these intra-arterial centres and the ganglionar and medullary centres, there are only sensory connections, fibres of association, of ortho- and anti-dromic conduction after the manner of Bayliss. The physiologists do well admit an influence of these intramural peripheric centres, but they seem to think that they only enter into activity after suppression of the medullary influence.

The facts which we have observed in man seem to show that they play a predominant rôle in the normal circulation, that, they alone, secure the motor actions, these actions being regulated by excitations, centrifugal and centripetal, coming from all parts of the body and going through the rami.<sup>13</sup>

One thing lacks to this hypothesis; that is the proof of degeneration after sympathetic neurotomy and this proof is indispensable for the elaboration of a valid theory of vasomotricity. We do not ignore that, up till now, the method of degenerations has led to conclusions absolutely contrary to the one which we had to adopt. Langley seems to have established through studies of degenerations that all the sympathetic cells gave rise to centrifugal fibres and never to centripetal fibres. Gaskell has concluded from his research that the sympathetic system was only made of motor fibres and did not include a proper reflex arch. Bayliss also has insisted on this characteristic of the sympathetic system.

However, the facts which we have reported do not allow to admit this conception. They also must be taken into consideration. And without wanting to propose a general theory on vasomotricity, we think that, from now on, the old theory should be discarded, the facts observed in man being incompatible with it.

<sup>13</sup> R. Leriche: Les indications et les résultats de la section des rameaux communicants dans la chirurgie de la douleur. *Grouement Belge d'étuds neuro-chirurgicales*, Novembre 14, 1926.

## SUTURE OF WOUNDS OF THE HEART

WITH REPORT OF A RECENT CASE

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ALTHOUGH the suture of wounds of the heart has ceased to be a strictly rare operation, it is sufficiently infrequent to be encountered by the individual surgeon perhaps only once or twice, if at all, in years of experience on an accident service. However, in view of the strict urgency of such operations every surgeon should be practically as well qualified to handle such cases as he would a patient who needed a tracheotomy. In 1920, Tuffier<sup>1</sup> assembled the reports of 305 cases of suture of the heart with a mortality of 49.6 per cent. The following case is reported not only because of recovery, but more especially because of the acquisition of complications in rapid succession, with a recovery from each in a manner almost unbelievable.

A colored man, J. D., taxi driver, aged thirty, was rushed into St. Louis City Hospital No. 2 on the 23d of October, 1926, with a history of having been stabbed in the anterior thorax during an argument one-half hour previous to admission. Following the accident, he had driven his taxi half way to the hospital when he fell over unconscious, wrecking the taxi, but apparently sustained no added injury to himself.

When seen in the examining room, the patient was unconscious, but tossing about so wildly that it was difficult to restrain him on the stretcher. He was covered with a cold sweat, his mucous membranes were pale, and he presented many of the other symptoms of profound shock. There was a small laceration 2 cm. long about 1 cm. to the right of the right sternal border in the fourth interspace. The radial pulse was 120 per minute, weak, and irregular, not only in rate, but more strikingly in volume. Heart sounds were very faint, and the same irregularity was noted. A pulse deficit of five beats per minute was present. There was no increase in the area of the cardiac dullness and neither was there any change in pulmonary percussion or auscultation. The blade of the knife, exhibited as the weapon which produced the wound, was broken about 4 cm. from the point. The broken end of the blade apparently remained in the wound. A hurried fluoroscopy revealed nothing of value except the broken end of the knife blade in a fixed position near the midline. Upon retrospection, the lower portion of the cardio-pericardial shadow seemed possibly a bit widened. During the ten or fifteen minutes consumed in examination, the patient's pulse became alarmingly weaker. He was taken to the operating room immediately with the diagnosis of active bleeding either from internal mammary vessels, intercostal artery, or cardiac injury. Since the symptoms resembled so closely the picture described following rapid increase in pericardial pressure, hemorrhage from the heart seemed most likely.

A three-inch incision was made under local anæsthesia along the right sternal border, just medial to the wound. The fourth and fifth costal cartilages were located, and 1 cm. of each removed at the sternal junction. Retraction of the wound revealed the internal mammary as well as intercostal vessels uninjured. In the mid-portion of the sternum was found the penetrating wound and just beneath the surface of the bone, the broken end of the knife blade could be seen. On account of the danger of renewal of hemorrhage,

the blade was not removed at that moment, but the bone cut away from it with a rongeur to allow exposure, if fresh bleeding started. When the blade was freed from its fixation by the bone, it was thrust out of its bed by the beating heart. This indicated quite clearly that the point of the blade was at least in approximation with the heart wall. Removal of the blade allowed a moderate flow of blood to escape through the laceration in the pericardium. This laceration was rapidly enlarged and a huge amount of fresh and clotted blood escaped. Practically immediately after the release of the pressure within the pericardium, the anaesthetist reported that a strong temporal pulse was palpable and the force

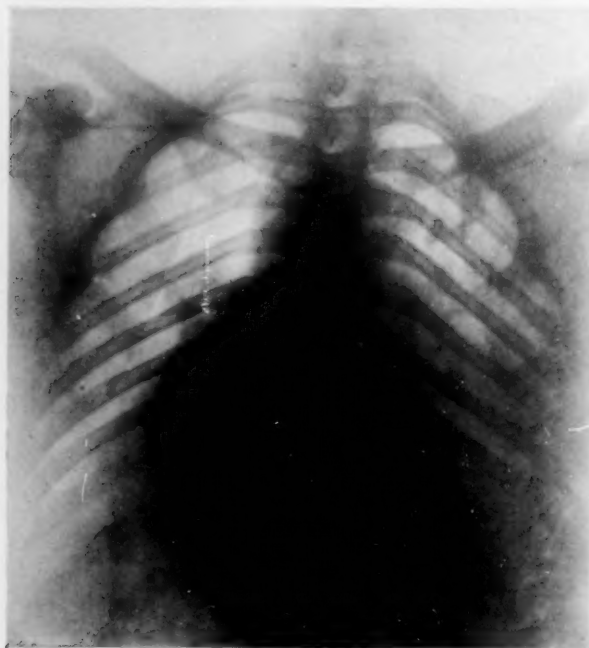


FIG. 1.—Röntgenogram of chest taken at St. Louis City Hospital No. 2 ten days after operation. Note pulmonary consolidation at right base and huge cardiac shadow. Because of the patient's critical condition, this is a portable film and taken in the antero-posterior direction. There seems to be a definite enlargement of the heart shadow, even though the röntgenogram was not taken in the routine postero-anterior direction.

of the cardiac contractions could be seen to increase markedly. The rhythm, likewise, returned to normal. After removing the bloody content of the pericardium by careful sponging, a ragged lacerated wound could be seen in the left ventricular wall about 1 cm. to the right of the coronary vessel. The force of the heart muscle against the fixed point of the knife blade had apparently enlarged and deepened the wound with each succeeding heart beat. This ragged wound measured about 1 cm. by 2 cm. and was bleeding quite freely. Exposure was so adequate that it was not considered necessary to apply a stay suture in the apex. Six or seven interrupted sutures were applied before the wound could be closed and all bleeding suppressed. The suture material used was o, twenty day cat-

gut, except for two final sutures of silk when the eye of the needle used for the catgut seemed to produce too much trauma. All blood and blood clots were then carefully removed from the pericardium and the pericardial sac closed. This tight closure was undoubtedly a grave error and will be discussed later. The rest of the wound was closed around a rubber drain which was inserted down to the dead space produced by removal of part of the sternum. Unfortunately, the patient thrashed about so wildly that ether anaesthesia became necessary before termination of the operation.

*Post-operative Course.*—The next day the patient's temperature was 105° F., pulse 140, slightly irregular and very weak, and respiration 60 per minute. There were signs of a beginning consolidation in each axillary base. Part of these signs were unquestionably due to a moderate pulmonary oedema. Heavy doses of digitalis and atropine as well as sufficient morphine were given. At the end of the second day, the patient's dressing suddenly became saturated with about 100 c.c. or 200 c.c. of serosanguineous fluid. A very definite improvement in his condition, especially cardiac, was noted almost immediately. The pericardial suture line had, no doubt, ruptured and a moderate heart tamponade had, therefore, been relieved. A frank consolidation of pneumonia developed on the left side

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and remained for ten days with a slight daily drop in fever. At this time the questionable signs of pneumonia in the right axillary and posterior base became definite and the temperature, pulse and respirations again rose. A moderately profuse bloody sputum was present, but became muco-purulent during the third week and was so foul that a lung abscess was feared. However, no auscultatory signs of lung abscess could ever be made out. After the apparent rupture of the pericardium on the second day, the heart sounds were always of normal intensity and so signs of increase in pericardial tension could be found at any time. A marked leucocytosis was always present, but reached its maximum of 36,000 at the time of development of definite pneumonic signs on the right side during the second week of his convalescence.

The drain was removed on the sixth day and the sinus tract almost healed on the tenth day when a slight purulent discharge manifested itself. This ceased during the fourth week and the sinus closed. Almost simultaneously a slight swelling manifested itself just above the right clavicle and the temperature and leucocytosis rose to a higher level. Within twenty-four hours, this swelling was quite definitely proved to be an abscess and was opened under local anaesthesia. Two or three ounces of pus were obtained and the abscess cavity found to extend down under the clavicle. The tip of the finger could not reach the lower wall of the abscess, which was quite certainly an abscess of the anterior mediastinum. Culture yielded a streptococcus. Four or five days later, the temperature dropped to normal. He was discharged at about the end of the sixth week of his convalescence.

He was admitted to Barnes Hospital a few days later for examination. The heart shadow in the roentgenograms was easily within normal limits, and no abnormal lung findings were made out. Electrocardiograms were normal. The sinus over the clavicle had closed by the end of the seventh post-operative week and since that time the patient has remained well.

The first man to suture a wound of the human heart was Cappelen<sup>2</sup> in 1895. The first patient to survive the operation was operated by Rehn<sup>3</sup> the following year.

It seems strange that such a vital factor, as danger of compression within the pericardium in traumatic heart surgery should be recognized so long ago as 1761 when Morgagni<sup>4</sup> called attention to it. It remained for Kuno,<sup>5</sup> however, in 1917, to demonstrate experimentally that when the pressure within

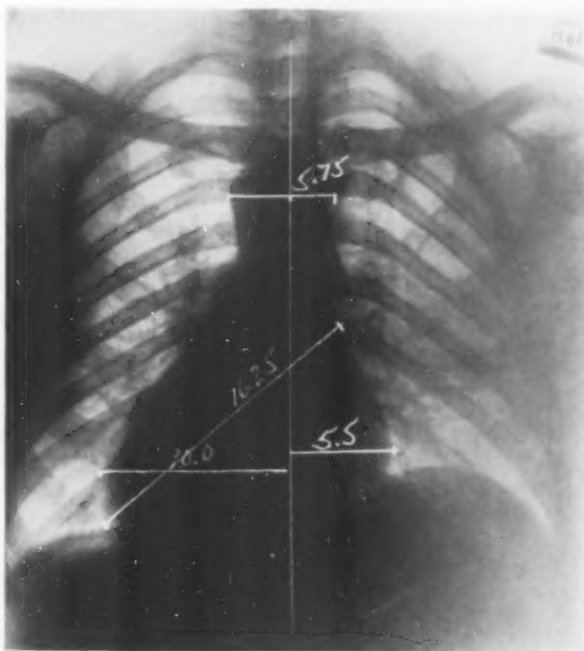


FIG. 2.—Roentgenogram of chest taken six weeks after operation. Nothing abnormal can be made out. The heart shadow is within normal limits.



the pericardium attained the height of the venous pressure, the heart ceased to function.

In a recent historical and very enlightening article, Beck,<sup>6</sup> of Cleveland, has very aptly stressed the importance of considering heart tamponade during the operative procedure and in the post-operative course of the patient. Probably his greatest contribution in that article has been the conclusive demonstration that, "as a precaution against tamponade, an opening in the pericardium 1 or

2 cm. in length should be provided in every operation upon the human heart." He demonstrated further that if the accumulation of fluid within the human pericardial sac exceeded 250 c.c. within thirty minutes, the heart would cease beating; likewise, that an amount in excess of 150 c.c. in the pericardial sac of a dog was fatal. These figures obviously apply only to rapid accumulations, since it is a well known clinical observation that if the process of accumulation extends over a longer period of many weeks, as

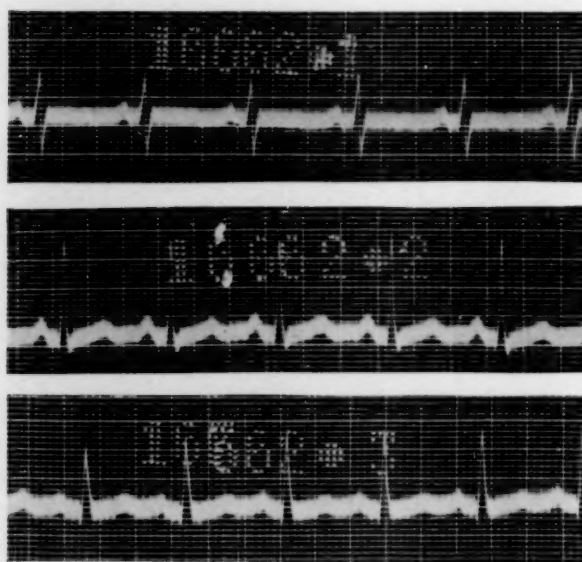


FIG. 3.—Electrocardiogram six weeks after operation. Report by Dr. D. Luten: P-R interval 0-16 sec. Rate 98, "T" waves isoelectric in lead I, upright in leads II and III. Considerable change in amplitude with change in position. Essentially normal electrocardiogram.

is seen in the effusions sometimes accompanying pericarditis, Pick's disease, etc., the amount may even exceed a litre in quantity.

The acceptable methods of approach and exposure are all identical or similar to the classical operations, that is, median sternotomy, consisting of splitting the sternum, or intercostochondral thoracotomy, consisting of retraction of the sternum after section of three or four costo-cartilages. The necessity of immediate release of pericardial pressure in traumatic cases seems to favor section of the cartilages and retraction. If exposure is inadequate, subsequent to this approach, a portion of the sternum can quickly be removed. This was done in the author's case, obtaining a perfect exposure of the ventricular portion of the heart. Subsequent observations on the patient have revealed no ill effects from removal of the portion of his sternum. Neither can a pulsation be felt over the area, thus suggesting that the increased susceptibility to trauma is insignificant.

The value of the preliminary application of a stay suture at the apex will depend largely upon the accessibility of the wound. If the wound is difficult of access, thereby requiring possible trauma of the heart muscle or conduction

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system to enable one to expose and repair it, the advantages are evident. However, in the author's case, exposure was so adequate that an apex suture was not deemed necessary. The first repair suture applied was left uncut and served very adequately as a stay suture, thereby aiding materially during the application of the remaining sutures. The value of adequate stay sutures will be very keenly felt if fresh hemorrhage is encountered during the repair, as happened in this case, when a branch of the coronary artery was injured with the needle. The wound immediately filled with a sea of frothy blood, but, with the aid of the stay suture as fixation and a guide, the bleeding was quickly controlled with pressure of the finger, and a ligating suture applied. Manipulation or handling of the heart in excess of that absolutely necessary in the repair is to be avoided. Although animal experimentation and observations on the human heart have shown that heart can be handled with hand, it has also been proved that manipulation which interferes with blood supply of heart muscle whether it be through coronary system or the base of the heart, may be rapidly fatal.



FIG. 4.—Photograph six weeks after operation. Note scars of healed wound over heart and of incised mediastinal abscess above right clavicle.

The two most important complications following repair of injuries of the heart are infection and reaccumulation of fluid within the pericardial sac. Obviously, if an opening is left in the pericardium at the time of the operation, any fluid which may accumulate will have opportunity for exit. In the series of cases reviewed by Tuffier,<sup>1</sup> about 50 per cent. of the fatalities were due to infection. Pericarditis, of course, is most to be feared, and jeopardizes seriously the patient's recovery. Pneumonia, likewise, is a very frequent complication and occurred in the base of each lung of the author's case. This would seem to have an easy and logical explanation, since thrombi would form readily in the injured coronary vessels, and if dislodged, would terminate in the lung

as emboli, with or without formation of infarcts. The occurrence of infection in the above process, whether it takes place in the heart or later in the lung, is assumed by many authorities to be frequently the precursor of pneumonia. The presence of the bilateral pulmonary œdema, occurring apparently as a sequella of cardiac embarrassment, possibly made the field more fertile for production of the pneumonia.

Surgery of the heart valves and interior of the heart offers a more complicated procedure, and is even more recent in practice than repair of cardiac injury. Vital steps have been taken in its advancement by the introduction of the cardioscope by Allen and Graham,<sup>7</sup> and the cardiovalvulotome by Beck and Cutler.<sup>8</sup>

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## PERICARDIAL DECOMPRESSION IN THE TREATMENT OF WOUNDS OF THE HEART AFTER CARDIORRHAPHY

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THERE can be no surgical procedure freighted with more anxiety than that of dealing with a bleeding heart. Fortunately, enough, injuries of the heart that are amenable to the surgeon's art are of infrequent occurrence. So seldom, indeed, that to prepare one's self for the emergency, should chance or circumstances ever bring it to our door, is so much like preparing for something in which an interest will never be given that an attitude of indifference has been taken by not a few of us. But when we reflect on what a deplorable exhibit this lack of being prepared would make of one; a nerveless bungler instead of a calm and deliberate surgeon who, having in mind, not only the necessity of a rapid and accurate pericardial decompression but the way to go about it as well, there is really nothing that could be said in justification of this attitude.

The motility of the heart is dogged, and yet, despite its doggedness, when bleeding from a wound fills the pericardial sac, there will come a compression within to which that motility must succumb. And when the threatening havoc is being foretold by a deepening cyanosis, air hunger and muffled heart sounds, what a comfort to know how a quick enough pericardial decompression will change the scene from one of dire despair to that of certain hopefulness.

"He Who Hesitates is Lost!" I like to associate this hackneyed quotation with the surgeon who may find such a condition confronting him. In their aggregate the five words of this old saying emphasize the expediency of his having to act quickly. Singly they may be likened onto five fingers pointing out the five steps of the operation that is imperative in the presence of such an emergency—namely, (1) a rapid and accurate chondro-plastic thoracotomy; (2) a rapid and accurate pericardial decompression; (3) a deliberate, though gentle delivery of the heart; (4) suture of the wound—(cardiorrhaphy); (5) cleaning the field and establishing drainage.

My first experience with a bleeding heart was a trying one. Trying because of my deplorable ignorance. I did not know how such an operation was performed for I had never seen the anterior mediastinum opened nor heard its surgery discussed. The best I could do was grope. Grope and bungle until an opening was effected. And then? Blood! Blood that gushed and flooded the field. Hard on this came the hissing of air from a torn pleura, and ere I knew what was the next best move to make, that pool of blood was being churned into a frothy, sickening spectacle.

As I view it now, the frenzied state into which my mind was forced may well be regarded as a just retribution for my lack of preparedness. And while

it may, in common justice, absolve me from the unsurgical dillydally sponging of the field, there has been less sting to the remorse of it because it was the very act, unsurgical though it was, that became the very means of bringing my finger tips in contact with the tightly distended pericardium. A distention so unyielding that immediately I was made to realize that the blood I had been mopping away was playing no part whatsoever in hurrying the death that was pending. What I was to do next now involved no question. Discarding the sponge in favor of a knife the submerged sac was slit in a longitudinal direction. Out came a gush of blood and clots so great that for the

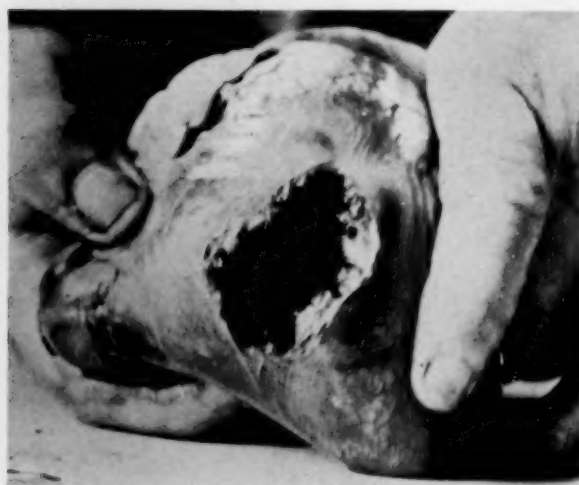


FIG. 1.—Experimentally produced stab wound that was made to enter the ventricle at right angle to its long axis. Note the almost complete tearing out of the ventricular wall.

moment it seemed enough to be fatal. But it was the very opposite effect that was noted. With the heart's freedom restored the threatening cyanosis began to pale. The change was nothing less than dramatic.

While irrelative to the subject under discussion, I will briefly mention another temper that laid hold on my mind when I had undertaken to lift the heart out of its sac. It struck my fingers with such an apparent directness that I actually recoiled. It gave me the sensation of having invaded the burrow of some unhappy haunted creature. There was a fear on me when, for the second time, I put my fingers beneath it.

When, on the palmar surface of my fingers, the heart was finally lifted from out the pool, its beating none the less for it, we beheld the wound. It was not a deep one. Only during diastole did it bleed. One mattress stitch and it was securely closed. Iron-dyed silk, popular at the time was the suture material used. The patient made an uneventful recovery. And the lesson that comes from his recovery, while not a surgical one, may be accepted as of equal, if not greater, value in seeing the heart's endurance, against such bungling, enabling it to see it through.

Innate fears can harass us but momentarily when it is duty that brings us to hold within our fingers' grasp the beating heart of a fellow being; nor can it be expected that head and hand remain cool and steady when, without previous training, they are forced to meet so trying an ordeal. The humility that this neglect brought me to bear during the stress of that operation with its blood drenched field—the mockery of the hissing pleura—the churning froth up pool—the horror of it all would have been spared me had I but



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known in advance that a bloody field awaited me. Had I but known that nothing, not even the bloodiest of fields, was to delay the vital step of the whole procedure and that that step was the pericardial decompression. And further, to have known that torsion must not be the means of bringing posterior heart wounds into view but instead to carry the apex forward toward where it would describe a vertical line with the base.

With the bleeding controlled, the field made clean, the heart dropped in place and then? To have it in mind *not to suture the slit in the pericardium*.

Why? Because effusion is inevitable to such an ordeal. An effusion that will be copious enough to reenact the same pericardial compression unless given ample room for escape. Nor should the sac be subjected to the irritation of carrying any form of drainage material within it lest the effusion be increased by that seeming intelligence of serous membranes in their effort to wash away a foreign substance.

Merely drain the anterior mediastinum for its floor is the pericardial sac and that has been left widely open. Of material, strips of rubber tissue, loosely rolled, are ideal.

Surgery of the heart will never be free from these besetting dangers that, at any unexpected moment, may thwart the skill of the best. It is in this wherein lies the risk of defeat. And while we know this, to flinch is to acknowledge that lack of courage kept away the realization that failing to act loses all.

There are many surgeons with that omnipotent ability that flowers only from years of the richest experience to whom an opportunity of dealing with an injured heart will never be granted. And again, the novice may be given it before he is sure of himself in any field. There is a lesson in this. A lesson no one can well afford to neglect.

Wounds of the heart may be roughly divided into two classes. Those that are immediately fatal and those that are not. The appearance of imminent death must never deter the hand, for there are enough of such cases on record to prove conclusively that a pericardial decompression under similar discouragements has, often enough, changed the scene from one of imminent death to one of assuring hopefulness.

The character of these heart wounds is but seldom ascertained. Nor



FIG. 2.—Experimentally produced stab wound that was made to enter the ventricle at an oblique angle to its long axis. The same knife that was used in the stab wound of Fig. 1.

would it be serving the best interest of the patient were one to undertake the necessary investigation. It is, however, enough for us to know that they occur in degrees from slight abrasions to through-and-through punctures. A puncture that enters the ventricle at a right angle with its long axis produces an almost instant death because the transit blood enters the wound as a dilator and tears out so great a portion of the ventricular wall that the moving blood within the entire system is brought to a sudden stop. Not so with a puncture entering the ventricle at an oblique angle with its long axis. Here,

the tract of the wound is caught between two opposing compressions.

The intraventricular pressure—the muscular contraction. That explains why these wounds close so tight at every systole. It also explains why they bleed only during diastole. That bleeding from oblique punctures during diastole into the ventricle can do no harm is too obvious for comment here. But that which oozes, trickles or actually spurts into the



FIG. 3.—Method of placing mattress suture to close puncture or stab wounds of the heart. We believe the soft, floss silk, with its tendency to flatten, the ideal suture material for these particular lesions.

pericardium must, if continued over a sufficient period of time, accumulate until the presence of the death-dealing pericardial compression becomes manifest. (See Figs. 1, 2 and 3.)

When placing the sutures the needle is made to pierce the muscle as deeply as may be possible without getting in too near the endocardium. It is also best to time the needle's thrust with each diastole, otherwise, cutting of the contracting fibres may obtain from over the needle's point. This rule holds good when the sutures are being tied.

When pericarditis with effusion, serous or purulent, is in need of drainage, it cannot be ignored that aspiration includes the hazard of wounding the heart. But should it be agreed that with a certain degree of skill one can thrust the pericardium with a needle without injury to its content, there will still be the disadvantage of having to rest content with having but a partial amount of the fluid withdrawn. Moreover, considering the readiness with which effusions recur we are immediately convinced that the procedure is destitute of the power to bestow a means lasting enough through which recovery could be effected.

Free, open drainage by a chondro-plastic flap of the fifth costal cartilage

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not only empties the sac completely, but, with the sac left wide open, the recurring effusion has an egress that will endure until the storm passes.

When pericardial compression is the result of accumulated blood from a wound, the flap is then made to include the cartilage of the third, fourth and fifth, perhaps the sixth, ribs.

It is not always an easy matter to diagnose those wounds of the heart that are going to require the surgeon's skill. There are too many differentiations for that, and besides, there are many conflicting and confusing points of distinction. However, and as a working guidance, we can do no better than to keep well in mind the advice of Rudolph Matas, when he says: "Visible external hemorrhage; hidden or concealed hemorrhage; and above all—*signs of heart compression*—call for immediate exploratory thoracotomy."

### REPORT OF CASES

CASE I.—A high speed emery wheel exploding hurled a number of its fragments throughout the grinding room of The Oil Well Supply Company's plant at Oil City, Pennsylvania. One of the workers was killed almost instantly. Another sustained a small puncture wound of the left chest between the sixth and seventh ribs just beneath the nipple. At the time I was on the surgical staff of the Oil City Hospital, where, within the hour following the accident, I saw him. There had been but slight bleeding from the wound. The pulse was, all considered, of good quality. His face bore a somewhat anxious expression; this we attributed to the pain he was complaining of and which I interpreted as a traumatic pleurodynia. For relief a hypodermic of morphine was given. Nothing present in his condition to make us in the least, apprehensive. But within the next two hours all this was changed. He grew fearfully restless. Cyanosis began to appear. The breathing quickened and became shallow. The heart sounds took on a far away distinctness, later the indistinctness of being muffled. Consciousness waned. This was the condition when it was decided to explore. I have already made my confession of groping and bungling through this operation. I need not recall the sin of that here. Still, a lesson may be glimpsed from it—a lesson that may serve to drive home an earlier statement of this article. I will repeat it. "The Motility of the Heart is Dogged."

CASE II.—Twenty years elapsed when, again, I was confronted with the same conditions, except that the heart had been wounded by a stab. The stabbing had taken place at about five o'clock in the evening. It was eleven o'clock of the same evening when I operated on him. This operation was performed at the Good Samaritan Hospital, Portland, Oregon. The knife had entered the chest between the eighth and ninth ribs with an upward thrust to pierce the pericardium just above its base and inflict a very slight cut over the heart's apex. In fact the cut was so shallow that suturing was not necessary. It had, however, bled enough to cause a menacing compression, and we reasoned, and rightly too, I feel sure, that it was the compression that had automatically arrested the bleeding. When the sac had been slit and the incarcerated blood turned out the heart's action immediately improved. Lifting it from the sac the character of the wound was made out and seeing it had ceased to bleed, it was deemed best to let well enough alone. This case recovered.

CASE III.—*Purulent Pericarditis*. It has, already, been touched upon how to secure adequate drainage in pericarditis with effusions. In this instance the compression was due to a purulent pericarditis in association with a streptococcic pneumonia which, with a pleurisy with effusion, involved the left lung. There was a leucocyte count of 38,000. We believed the fluid in the chest to be pyogenic in character, but the needle disclaimed this belief. Five pints, about, were aspirated, and the fluid being the usual pale, straw-

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color, we puzzled over so high a blood count. Finally, when the signs of heart compression began to appear, and later still, when it was claimed that thoracotomy was the only alternative, we found on opening into the anterior mediastinum the bulging sac. It was, to my finger-tips at least, as tense as those I had met before, but without that ugly overlying pool of blood. In color it was of that yellowish-whiteness that left no doubt as to the nature of its contents. This case I operated on at the Japanese Hospital in Honolulu. A liberal slit in the pericardium with free drainage from the anterior mediastinum through the lower border of the chondro-plastic flap brought this case to an uneventful recovery.

## PURULENT PERICARDITIS IN CHILDHOOD\*

BY ERNEST G. WILLIAMSON, M.D.

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DRAINAGE of the pericardial sac was first recommended by Riolan<sup>1</sup> in 1648, who suggested trephining the lower end of the sternum for this purpose. There is no record of Riolan having put into practice his suggestion. In 1798, a century and a half later, Desault and Larrey attempted to evacuate the pericardial sac by different routes, but both failed because of mistaken diagnosis. Laënnec in 1819 again advised Riolan's plan of trephining the sternum. The first successful pericardiotomy was done by Romero,<sup>2</sup> of Barcelona, who in 1819 operated upon three patients, two successfully. He incised the chest in the fourth and fifth interspaces near the sternum. First rib resection was performed by Rosenstein, of Leyden, in 1881.<sup>2</sup>

The practice of paracentesis of the pericardium gained much impetus in America by the work of John B. Roberts<sup>3</sup> and his report of 41 cases in 1876. The prejudice against the procedure up to this time is shown by Rogers who is quoted as saying, "Paracentesis of the pericardium remains always an operation of urgency; contra-indicated in a general way every time we have reason to suspect a case complicated with some incurable lesion, applicable especially to large acute and chronic effusions of rheumatism and to chronic effusions of which the diathetic nature is not evident. . . . In the immense majority of cases it is only palliative." Roberts suggested the treatment of suppurative pericarditis by insertion of a drainage tube into the pericardial cavity, but apparently had not performed such operation.

The first reported case with operation is by Hilsman in 1844.<sup>4</sup> From that date to 1897 Roberts<sup>4</sup> collected and reported 35 operated cases, 15 recovered, 20 died.

Although comparatively few cases of suppurative pericarditis have been reported, 117 to date, it is apparently a fairly common condition. Autopsy records of the Harvard Medical School, 1896 to 1911, covering 3248 autopsies, shows 366 cases of pericarditis, 6 being purulent.<sup>5</sup> Cnopf found 7 cases of suppurative pericarditis in a total of 130 autopsies. Wood<sup>6</sup> reports that acute pericarditis is found in 4 per cent. of all autopsies. Maclachlan<sup>8</sup> reports that in the University of Pittsburgh Hospital an examination of the autopsy records shows 100 cases of pericarditis in some form in 975 cases. Very few were purulent. Whitmore<sup>7</sup> reports that records of the Massachusetts General Hospital show but two cases coming to operation in thirty-two years. Records at the Children's Hospital in Philadelphia for the past thirty-two years show none but the case being reported coming to operation. Therefore the question—how many cases are being missed in all of our hospitals?

In 1897, Roberts<sup>4</sup> compiled a list of all reported cases to date. He

\* Read before the Philadelphia Academy of Surgery, January 3, 1927.



reported 35 cases. Porter<sup>12</sup> in 1900 reported an additional 16 cases. In 1909, Eliot<sup>17</sup> added 22 cases. Rhodes<sup>2</sup> in 1915 reported 13 and in 1921 Poole<sup>14</sup> brought the literature to date with a report of 13 cases. I wish to add 18 cases bringing the total number to 117. Of these there were 31 patients between the age of six and twelve. From sixteen months to sixteen years there were 50 cases. Of the total 117, there were 63 recoveries and 54 deaths, or 54 per cent. cures. In the children there were 25 recoveries and 25 deaths, or 50 per cent. cures. By cures is meant recovery from operation and subsequent discharge from the hospital with pericardial infection cleared. The details of most of these cases are meagre, so a report cannot be made on the number of cases with normally functioning hearts one or more years after operation.

The cause may be direct extension by contiguity or through the blood. In most cases the condition is secondary to some other focus of infection.<sup>6</sup> In children it usually follows acute exanthematous diseases, but may follow a septic process anywhere in the body—such as osteomyelitis, otitis and mastoid disease. Pneumococcus is the organism most frequently found. Other organisms have been—staphylococcus, streptococcus, Frankel's diplococcus, *B. pyocyaneus*, *B. tuberculosis*, *B. coli communis*, *B. influenza* and rarely *B. lact. aerogenes* and *B. proteus vulgaris*. In the pneumococcic type the pus is less abundant, thick and creamy. In the streptococcic there is abundant thin pus and the membrane is only slightly thickened.

The symptoms are divided by Rhodes<sup>2</sup> into three stages: (1) A small amount of pus present—symptoms only constitutional. (2) In which there is an increase of exudate up to the limits of elasticity of the sac. This is the stage usually seen—and gives the classical symptoms and signs of pericarditis with effusion. (3) The elasticity of the sac is overcome by the amount of exudate; this stage is called by Rehn the "Herzdruch." It is produced by the intrapericardial pressure exceeding the intra-auricular pressure. The case to be reported illustrated this stage when one day near the close of the drainage period, on irrigating the sac with a tube that did not allow free return of the fluid, the patient suddenly became cyanotic, showed great respiratory embarrassment, the veins of the neck became distended, pulse irregular and complaint made of precordial pain, oppression in the chest and pain in the left arm. Rhodes<sup>2</sup> reports a similar experience, as do also Blake and Parker.

A diagnosis is made by the history, recent infection; fever, usually septic in type; rapid pulse, dyspnoea, restlessness, possibly cough, and precordial, epigastric or abdominal pain.<sup>6</sup> If moderate effusion—palpitation, dyspnoea, and increase of respirations do not occur. The pulse is rapid but regular. As effusion increases dyspnoea, orthopnoea, cyanosis, and rapid, irregular heart occurs. There is high fever and sweating in septic cases.<sup>6</sup> Wynter<sup>10</sup> states that loss of abdominal respiratory movement is an accompaniment of pericarditis. The X-ray aids greatly in arriving at a diagnosis. The physical signs are those of pericarditis with effusion and need no discussion. The

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condition most frequently confused with pericarditis with effusion is dilated heart. Roberts<sup>4</sup> urged exploratory incision down to the heart in patients with urgent symptoms that might be due to either condition—then aspirate if no pus and drain if pus.

The question of paracentesis in either diagnosis or treatment is an interesting one. Rhodes<sup>2</sup> states that it is emphatically condemned. LeConte<sup>11</sup> says exploratory puncture is an essential procedure in making a diagnosis. Roberts<sup>4</sup> prefers incision and exploration rather than aspiration. The dangers are, puncture of the internal mammary artery, puncture of the heart muscle or large vessels and the lung. The danger most frequently dwelt upon is that of puncturing the pleura and carrying the infection into the pleura and lungs. Sick<sup>12</sup> found in the adult that out of 23 cases, in 17 the pleural reflection at the level of the fifth rib cartilage lay at or within the sternal border; and in 12 children it was in the same location in 11.

The site of puncture is another point of great variance. Roger<sup>3</sup> advises the fifth interspace midway between the left nipple and the sternum, penetrating directly backward. Dieulafoy—the fifth interspace three-quarters of an inch from the edge of the sternum; because experiments conducted by him showed the greatest amount of distention here. Hobart A. Hare, Delome and Mignon prefer the sixth interspace. Laënnec, Boyer, Richerand, Müller and John B. Roberts<sup>1</sup> prefer the left costoxiphoid notch close to the ensiform cartilage, etc.

Treatment consists of incision and drainage. Klose and Strauss<sup>20</sup> collected a series of 93 cases and reported that of 29 cases treated by puncture alone but 4 recovered. Of 27 treated by intercostal incision 10 recovered. Of 37 treated by wide exposure of the pericardium 21 recovered. Whitmore<sup>7</sup> reports a case successfully treated by the closed suction method. He describes his operation as follows: "Novocaine anaesthesia. Incision three-quarters of an inch long in the fifth interspace just inside the border of dullness. Anaesthetize muscles, pericardium and pleura, if in the way. Push a large trocar, with cannula large enough to carry a No. 10 French catheter, through the pericardial wall. Quickly slip No. 10 French catheter, with end closed by a hæmostat, through the cannula. Push the catheter in far enough for the tip to go around the apex of the heart and half-way up to the base (8-9 inches from the skin). Sew catheter in tightly. Make suction with a large glass syringe and allow no air to enter the pericardium. Empty pus slowly. Suction is done every one to two hours for the first twenty-four hours, and then every two hours until but 3 to 4 c.c. is obtained at a time. Then lengthen the time to three or four hours and later to twice in twenty-four hours. When the amount is only 1 to 2 c.c. in twenty-four hours and this amount does not increase for four days, the catheter is removed." In the case reported the catheter was removed at the end of the fourth week. It is doubtful if this treatment would be successful after fibrin has formed, and as but few cases are seen in the hospital before this stage is reached, it will be seen that it has a definite limitation.

The treatment of greatest value is the removal of one or more costal cartilages, and in some instances removal of a section of the adjacent sternum. Doctor Brown, in the case to be reported, following the method of Durand,<sup>1</sup> resected the fifth costal cartilage and a section of the adjacent sternum. Very good drainage was obtained and the opening was large enough to permit ready identification of the various structures so that the pleural reflection was not damaged. Durand and Wertheimer<sup>13</sup> treated their case by resection of the seventh costal cartilage and the lower portion of the sternum. Poole,<sup>14</sup> in his recent survey of the subject, suggests resection of the fifth, sixth and seventh costal cartilages adjacent to the sternum. He feels it is essential to have drainage in the most dependent portion of the sac. Roberts<sup>4</sup> suggests a chondroplastic operation—resection of the fourth and fifth costal cartilages on the left side of the sternum and turning the flap of cartilages, muscles, and skin upward. He does not think it is essential to have drainage at the most dependant portion. Porter<sup>12</sup> advocates incision from the middle of the sternum out over the fifth cartilage and resection of the fifth cartilage from sternum to rib.

The advantage of a drainage tube inserted into the pericardial sac is doubtful. In most of the reported cases this was not used. Drainage was provided for by making adequate opening and suturing the edges of the incised pericardium to the skin opening. It seems to the author that the movements of the heart tend to preclude the formation of pockets. Most observers have noted that in effusion the heart is pushed forward against the anterior chest wall. Therefore if at the time of the operation all pockets are broken down they probably will not reform.

Poole<sup>14</sup> advocates the treatment of these cases by the Carrel-Dakin method. In Doctor Brown's case the pericardial sac was irrigated with warm normal saline solution until the twenty-fourth day. As the fibrin seemed to be accumulating, rather than decreasing, it was decided to use the Carrel-Dakin treatment with result that the amount of fibrin and discharge began to show a marked decrease and the patient's temperature began to assume a downward trend. Roberts and others agree that there is no good reason to suppose that irrigation with a mild antiseptic causes any cardiac disturbance. He suggests that this is so because the reflex irritability of the heart is modified by the false membrane.

Jopson<sup>10</sup> in discussing Poole's paper, when read before the Academy of Surgery (Philadelphia), reported a case in which he tried Carrel-Dakin treatment, but discontinued it because the thick mixture of the exudate and solution caused embarrassment to the heart's action.

Beck and Moore,<sup>15</sup> in recent experiments on the normal pericardium, conclude that it is a delicate structure and that slight irritation, even irrigation with warm normal saline, usually results in firm adhesions between the two layers. This evidently does not apply to the infected pericardium for in the case to be presented, there is to-day no evidence of a heart crippled by adhesions to surrounding pericardium.

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Hall<sup>18</sup> reports a case, diagnosed acute septic pericarditis, which yielded to intravenous injection of 15 c.c. of a 1 per cent. solution of mercurochrome. The patient had had a tooth extracted five days previous. There is no record of a culture on this admission to the hospital and no record of a paracentesis to confirm the diagnosis.

The treatment of the infected pericardium is not sufficient in the treatment of these cases. It is likely that in all these patients the myocardium is markedly diseased, as evidenced by palpitation, tumultuous heart action, dyspnoea, tendency to syncope, cyanosis and finally signs of cardiac failure, as anasarca and ascites. Doctor Brown's patient showed this condition to a marked degree and required frequent tapings, and energetic medical treatment. To the cases previously reported I add the following:

White male, age seven years. Admitted to the Children's Hospital in the service of Dr. Henry P. Brown, Jr., September 26, 1925. Temperature 99.6, pulse 144, respiration 40. Previous history, negative except for pertussis several years ago.

Present illness (as given by the mother). Onset seven weeks ago with cervical adenitis followed by ptomaine poisoning, vomiting and urticaria. This was followed in a few days by abscess on left shoulder, posteriorly. Taken to another hospital where a diagnosis of pneumonia was made. The child was critically ill and the parents were told nothing could be done for the child and they took him from the hospital.

History in this hospital shows the patient was admitted August 27 with temperature 104, pulse 100, respiration 32. He had a fluctuating tumor over the left scapula which was incised but no pus obtained. A note on the chart stated the contents appeared to be gelatinous. Following this he had symptoms and findings in the left chest thought by some of the men to be patches of pneumonia. During this time his temperature fluctuated from 101 to 98.4. On September 2, X-ray men reported, "Heart shadow not enlarged. Left lung shows area of consolidation from root to base upper lobe, suggestive of encapsulated abscess."

Repeated exploratory punctures of the left chest failed to reveal pus. Some thought the mass in left chest involved mediastinal tissues and not heart nor lungs.

September 4 the pulse rate jumped to 150 and remained up.

X-ray on September 25 showed heart shadow enormously enlarged to the left.

Diagnosis of serofibrinous pericarditis was made and the parents removed the child against advice of the physicians. Paracentesis pericardii was not made.

Examination on admission showed an emaciated boy who appeared to be critically ill. He was cyanotic; breathing was difficult and rapid. Frequent hacking cough. Anxious expression. Very restless. Skin dry. Conjunctivæ reddened. Pupils dilated. Nares dilated with each respiration. Marked pulsation in vessels of the neck.

Chest shows rapid respiratory excursions. Breathing entirely thoracic. Recent crucial scar over the left scapula. Skin over chest, mottled and dry. Resonance impaired at left base anteriorly. Many fine, crackling râles over both bases and extending to axilla. No evidence of fluid in pleural cavity.

Heart—dulness markedly enlarged to right and left. Sounds, distant and irregular. Unable to elicit friction rub or murmurs. Apex beat, not visible. Posteriorly there was area of dulness in region of the angle of the scapula.

Abdomen, somewhat distended. Liver edge, four fingers' breadth below the costal margin; edge smooth, rather tender. Spleen and kidneys not palpable.

X-ray on admission, September 26, 1925, by Doctor Bromer, reports, "Marked increase in density in left chest from apex to diaphragm. Right lung shows less increase in density from apex to seventh rib. There is extreme increase in the width of the right

auricle shadow, and of the left ventricle, and also of the base of the heart. I think this is due to a pericardial effusion. Lung density could be due to a passive congestion."

September 27—Coughs considerable, non-productive. No pain.

September 28—Paracentesis pericardii, fifth interspace close to the sternum, by Doctor Reilly; 7 or 8 ounces thin purulent fluid removed, with quite marked relief of symptoms.

September 30—Dr. H. P. Brown under novocaine anaesthesia resected the fifth costal cartilage and adjacent portion of the sternum. Internal mammary artery ligated. Pleural reflection pushed aside. Pericardium incised. Culture taken. Considerable thin purulent fluid allowed to slowly escape. Pericardial opening edge sutured to skin edge. Large rubber drain inserted through the chest wall to the inner level of the pericardium. Rest of wound closed with silkworm gut sutures. Child stood the operation well and returned to the ward in fair condition. Culture—*Staphylococcus aureus*, hæmolytic.

Progress.—October 1—Child sleeps fairly well in sitting position. Pulse 160, temperature 101, respiration 34, pulse intermittent, but volume fair. Forcing fluids.

October 3—Wound draining freely. General condition much improved. Pulse intermittent, rate 100. Liver three fingers below costal margin. Spleen not palpable. Given digitalis in large doses.

October 5—Pulse 160, temperature 103, respiration 48. Child coughing a great deal. Wound draining moderately. Irrigated with warm saline. Considerable fibrin present.

October 7—Quite ill. Given blood transfusion, father's blood. General condition improved following transfusion.

October 9—Pulse again very rapid and weak. Patient's condition is grave.

October 13—Large amount of fibrin about the opening of the cavity. Temperature has been fluctuating between 103 and 99. Curved hæmostat passed through opening, behind the heart and opened failed to reveal any pus collection.

October 17—Quite weak. Considerable discharge from the wound. Given more stimulation—chiefly whiskey and digitalis.

October 22—Discharge less in amount but contains considerable fibrin. Temperature still fluctuating from 103 to 99. Pulse from 160 to 120, but is more regular, skipping beat but once in 40 beats. There has been œdema of right forearm for past three days. Right chest aspirated in posterior axillary line, seventh interspace, and 480 c.c. clear, straw colored fluid removed. Two Dakin tubes were inserted through pericardial wound and carried just into the sac. Carrel-Dakin treatment started.

October 26—Discharge less and thinner. Temperature fluctuating from 100 to 98.2.

October 28—General condition much improved. Right chest aspirated and 480 c.c. straw colored fluid removed. Liver extends to within ( $1\frac{1}{2}$ ") of umbilicus.

October 30—Discharge small in amount, thin. Smears show 8-10 organisms to a field. Breathing much easier.

November 5—Very little discharge. Cultures show slight growth—*staphylococci*. Right chest aspirated—300 c.c. straw colored fluid removed. Pulse still around 140. Temperature 98-99.

November 6—Smears show but 1 or 2 organisms to a field. Dakin tubes removed.

November 10—Temperature normal. Pulse 130. There is a swelling in right side of neck about the size of a pigeon's egg—under the sterno-mastoid muscle; slightly tender. Patient complained of pain and tenderness in calf of right leg—no swelling. Liver two inches from umbilicus. When pericardial sac was irrigated 20 c.c. Dakin's solution was put in, but the tube did not permit free exit of the fluid and patient went into the state of so-called, "Herzdruch"—becoming dyspnoeic, cyanotic, and complaining of pain in left chest and abdomen. He was relieved by permitting free exit of the fluid.

X-ray shows heart shadow much reduced in size. Less fluid in right chest.

November 14—Swelling noted on November 10, has disappeared. Patient permitted out of bed in chair. Sinus still present—very little clear discharge.



## PURULENT PERICARDITIS IN CHILDHOOD

November 16—Wound healed. Probed, when one dram of clear fluid was obtained. Right chest aspirated—300 c.c. clear fluid removed.

November 19—Pulse now quite regular, rate 120. General condition good.

December 8—Patient up and about the ward. Gaining weight. Lungs show good expansion—no evidence of fluid in pleural cavities. Heart—area of dulness, but slightly increased. Wound healed. Pulse rate 90-110, regular and increased but slightly on exercise. Liver still a little enlarged.

December 17—Discharged. Gaining weight. Color good. Quite active and pulse remains regular, rate 86-96. Heart regular, sounds clear, no friction, no retraction of superficial structures. Liver almost normal in size, not tender. No œdema of extremities. Referred to heart clinic for observation. Weight on discharge, 47 pounds.

February 6, 1926—Notes from heart clinic. Weight 55 pounds 6 ounces. General condition good. Cardiac dulness in fourth interspace is 7 cm. to left and 3.5 cm. to right of mid-sternum.

March 3, 1926—Heart slow and sounds clear. No evidence of faulty action of the heart.

November 13, 1926—Seen by Doctor Brown. General condition excellent. Heart action regular; no evidence of pericardial adhesions. No dyspnoea on exertion. Gaining weight. Mother states he was never better.

### REPORT OF CASES REPORTED SINCE THE PAPER OF POOLE<sup>14</sup> IN 1921

1. DURAND and WERTHEIMER<sup>15</sup> report case of male, age thirty-seven. Operated nine days after admission (August 9, 1919). Patient had infected hemopericardium after stab wound. Treated by resection of seventh costal cartilage and lower portion of the sternum. Recovery.

2. CASSIDY, M. A., MOON, R. O., PEELY, F. LEQ.<sup>16</sup> reports male forty-two, who was seen in attacks simulating Angina-pectoris. There was history of three separate attacks of gonorrhœa in two years. He died three days after admission. No operation. Autopsy revealed suppurative pericarditis, thought to be gonorrhœal in origin.

3. WHITEMORE<sup>7</sup> reports boy, age twelve years. Seen May 8, 1920. Previous history of measles with normal convalescence. On April 27, day following recovery from measles, he was taken with sudden chill and high temperature. On May 8, pneumonia right base and empyema left side chest. Closed suction operation. On May 15; temperature 100-102, respiration 35, pulse 110. X-ray showed heart shadow enormously increased. Aspiration revealed thin pus. Culture, pneumococcus type 1. Drainage by closed suction. Good recovery. Patient had to have bilateral mastoid operation before discharge from the hospital.

4. KLOSE, H., and STRAUSS, H.<sup>20</sup> operated on a man of forty-one years, who had marked adhesions to surrounding mediastinal structures. He died a few days later.

5 and 6. HILSE<sup>22</sup> reports two cases in which there were adhesions between the heart and pericardium. One, male nineteen, operated on by Ollier's method, died. The other a male, age twenty-seven, operated upon by Rehn's method got well although examination on discharge from the hospital showed retraction of the chest wall and diaphragm with each heart beat.

7. GAMBERINI<sup>21</sup> operated on male, age seven years. A second operation was necessary sixteen days later because of insufficient drainage. At second operation a section of the sternum was resected and drainage was instituted posterior as well as anterior. Fistulæ persisted for some time—5 or 6 months. There was recovery with good health four years later.

8. In APPEL'S<sup>6</sup> case, a boy, age twelve years, a pulsating mass appeared at the left border of the sternum at fourth costal cartilage. This was found to be infected pericardium and was drained. Patient died.

9. ORSINI<sup>26</sup> reports male, age sixteen years, admitted December 3, 1921 with signs of pneumonia. Aspiration on December 23 revealed pus in the pericardium. Patient died.

10 and 11. JOPSON<sup>15</sup> and MULLER<sup>21</sup> in discussing Poole's paper each reported a case, Muller's patient, male of sixteen years, recovered. Jopson's patient, adult male, died.

12. DUFOUR and BARUK<sup>30</sup> report a patient, age twenty-two, admitted to the hospital with vomica. Pleural cavity explorations were negative. Paracentesis pericardii revealed purulent fluid. He died without operation. Autopsy showed communication between posterior portion of pericardial sac and bronchi.

13. MUNIAQURRIA and ZENO.<sup>27</sup> Male, four years. Pericardiotomy with drainage on July 12, 1923. Good recovery. Child showed positive tuberculin test and was thought to have pulmonary tuberculosis. Question if pericardial condition was of tubercular origin.

14. COTLIN, MILE and GANTIER<sup>31</sup> through the fourth interspace aspirated the pericardium a number of times in a male, six and one-half years old. Recovery.

15. HALL and TOWNROW<sup>32</sup> report, male seventeen, who was admitted to the hospital on September 26, 1923, with primary pneumococcal pericarditis. Paracentesis pericardii gave considerable relief. Paracentesis on October 1 was followed by resection of the fifth rib and drainage. Empyema of left pleura, thought to be secondary to the pericardial infection was drained on October 31. Patient was discharged December 11 and was in good health one year later.

16. WOOD and BRADLEY<sup>6</sup> had a patient, male, age four years and nine months, admitted April 8, 1923, following measles. Diagnosis on admission, broncho-pneumonia. April 12 they drained the second left interspace for a collection of pus. Drainage ceased in five days. Needle inserted deeply through the wound revealed more pus. Pericardiotomy on April 21, after resection of the third rib. Irrigated with Dakin solution. Drainage poor and wound had to be opened several times. Wound healed and on May 6 patient was discharged in good condition.

17. ADSHEAD<sup>33</sup> in Royal Naval Service treated male, twenty-two years, who was admitted to the hospital with double pneumonia on April 18, 1925. On May 1 pericardial effusion was noticed. Paracentesis pericardii on May 3; pneumococcal pus, fifth left costal cartilage and part of the rib was resected on May 4. Pericardial sac irrigated with acriflavine and hypertonic salt solution for three weeks. Patient developed general ascites and urine showed cloud of albumin and red blood cells. Ascites aspirated. July 24 a large abscess posteriorly between the base of the lungs and dome of the diaphragm was drained. This was followed by speedy recovery.

18. Doctor Brown's patient—case reported.

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## PHLEGMONOUS GASTRITIS<sup>1</sup>

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PHLEGMONOUS gastritis is a rare condition described since ancient times, beginning with Galen. It is an infection of the stomach wall characterized by sero-purulent or fibrino-purulent inflammation, chiefly localized in the submucosa, but more or less involving other layers. It may occur either as a phlegmon or as an abscess or as a combination of the two. The phlegmon may be diffuse or circumscribed. In ancient literature, only the abscess form was recognized.

The first accurate pathological description of a phlegmon was made by Cruveilhier (1820). In Raynaud's collection (1861) half the cases were abscesses, and the other half phlegmons. Later, with the advent of abdominal surgery, phlegmons were more easily recognized so that in Sundberg's collection of 215 cases (1919), 85 per cent. represented phlegmons, 12 per cent. abscesses, and 3 per cent. a combination of the two. Of the 185 phlegmons, 158 were diffuse, and 27 circumscribed.

With the larger material available during recent years, it is apparent that the process may vary greatly in its intensity, as illustrated by certain subacute and chronic types to be mentioned later.

The acutely inflamed stomach wall is usually dense and rigid,<sup>2</sup> but in some cases may be of soft, spongy consistency. Thickening of the wall may be little more than normal, or may reach a degree described in Hall and Simpson's case, where relative size of wall and cavity bore a striking resemblance to that of the uterus. Circumscribed phlegmons and abscesses occur more frequently in the pyloric region than elsewhere. Abscesses of the stomach wall have been known to reach the size of a Bartlett pear. While most phlegmons can be diagnosed grossly, a definite number of others merely show an acute swelling, the character of which can only be determined by microscopical examination.

The mucous membrane is at times unchanged, both on gross and on microscopical examination, at other times, all varieties of thickening and all degrees of cedema as well as hyperæmia, punctiform hemorrhages, hemorrhagic erosions, and ulcerations, may be found. Moreover, there may be perforations of the mucosa, thus permitting spontaneous drainage into the gastric cavity. Involvement of the muscularis and serosa is common. Peritonitis occurs in from 60 to 70 per cent. of the cases, but is not invariable. In one-third of the fatal cases there was no peritonitis (Sundberg). Left-sided pleurisy, pericarditis, and bronchopneumonia have been complications.

<sup>1</sup> Read before the New York Surgical Society, January 12, 1927.

<sup>2</sup> Virchow, at the autopsy on a case of Ackerman's, remarked that if such a condition involved the skin it would be called a carbuncle.

## PHLEGMONOUS GASTRITIS

Streptococci are the organisms most frequently found (70 per cent.); but staphylococci, pneumococci, *B. coli*, and *B. subtilis* also occurred.

Phlegmonous gastritis occurs mostly in the working classes, and is three times as frequent among men as among women. The majority of the patients are between twenty and sixty years of age.

As constitutional predisposing causes may be mentioned, exhaustion from hard labor, alcoholism, chronic gastritis, and hypoacidity of the gastric juice. The bactericidal properties of normal gastric juice and, conversely, the increased likelihood of infection definitely associated with low acid figures, must both be taken into account. Sundberg states that there was no history of hyperacidity or even of normal acidity of the gastric juice in the cases he reviewed. This observation is confirmed in a majority of the cases which the author has been able to collect since that time, in which gastric analyses were reported. In this connection a report of Stieda is of interest. In 64 cases of gastric operation on patients with low acid values, post-operative infections developed in 17 (30 per cent.), while in 35 cases in which the acidity was high or of normal value, there were only 2 (6 per cent.) cases of infection.

Bumm's recent experiments *in vitro* demonstrate the antiseptic qualities of normal gastric juice. He maintains that in anacid stomachs bacteria remain alive. If stagnation be present, the products of decomposition favor bacterial growth and increased virulence.

There are a few instances in which trauma has played a definite etiological rôle. In chronic gastritis the mucosa is more susceptible to trauma than when normal, and it must also be remembered that streptococci can penetrate mucous membrane without causing a local reaction at the point of entry. Actual injury to the gastric mucosa by chemicals and drugs or by the poisons of spoiled food (see below) is occasionally noted in the etiology. External trauma, such as that caused by the kick of a horse or a fall from a scaffold, striking the epigastric region, is of occasional etiological importance. Gastric phlegmon has been associated with ulcer or cancer of the stomach in over 50 cases.<sup>3</sup>

Phlegmon of the stomach rarely occurs as part of a general sepsis with purulent metastases in various organs. On the other hand, certain unknown predisposing factors may exist, for it was noted that during a large epidemic of puerperal sepsis in Prague in 1847, several cases of phlegmonous gastritis were observed among those coming to autopsy. Cases of phlegmonous gastritis are also seen following erysipelas<sup>4</sup> or furunculosis.

A man of forty-nine years (reported by Sundberg), suffering from chronic pulmonary tuberculosis, after five days' ingestion of potassium iodide, developed a severe pustular acne; his general condition became poor; and he died within a week. At autopsy a large recent ulcer at the pylorus was found, while in other parts of the mucosa there were areas of suppuration varying in size from a pea to an almond, with

<sup>3</sup> See Cases Nos. 45, 46 and 47 in appended table more fully reported as Cases I, II and III in text.

<sup>4</sup> See Cases Nos. 10 and 45 (Case I in the text).



small perforations into the lumen of the stomach. Similar lesions existed in the duodenum and upper jejunum. These suppurative foci grossly resembled the acne pustules of the skin and the larger ulceration at the pylorus was held to represent a carbuncle. Microscopical examination of the uninvolved gastric mucosa showed chronic gastritis.

Besides erysipelas, furunculosis, and puerperal sepsis, as just noted, gastric phlegmon has occurred in connection with smallpox, scarlet fever, acute polyarthritis, and pyæmia.

Direct contact of the gastric mucosa with infectious material has also been followed by phlegmon. For example, it has occurred after tonsillitis, stomatitis, pharyngitis, purulent bronchitis, drainage of abscesses of the oral pharynx, and extraction of carious teeth. In one case it followed a meal of calf's liver from an animal which had probably died of sepsis. In another instance, all the guests at a party became gravely ill after a meal, but only one died, and autopsy showed a phlegmonous gastritis.

Lastly, there is a large group in which no ascertainable cause exists—the so-called primary idiopathic form.

The typical symptoms are: Sudden onset, with profound prostration, high fever, chills, intense epigastric pain and tenderness, repeated severe vomiting, and more or less local rigidity. A symptom first noted by Deininger (1879) and occasionally confirmed since then is lack of pain when the patient is made to sit up. This symptom was observed by Sundberg independently. In some cases of spontaneous recovery from gastric abscess, a definite tender epigastric tumor has developed in the course of days, and spontaneously subsided after the vomiting of pus. Graphic descriptions of these are quite frequent among the earlier reports.

The vomiting of macroscopic pus or the presence of bacteria in the vomitus are rare. Macroscopic pus in the stools has occasionally been noted. As a rule, the white blood cell count is high—between 20,000 and 30,000. Extreme restlessness up to within a few hours before death has been noted; in other cases there was marked apathy.

Diagnosis is rarely made before operation. Usually the condition is mistaken for acute perforated gastric ulcer, acute pancreatitis, or acute cholecystitis. High fever and lack of increased pain upon sitting up (Deininger's symptom) speak for gastric phlegmon as against perforated gastric ulcer. Before the onset of peritonitis (as noted elsewhere this was absent in one-third of the fatal cases) abdominal puncture would be negative, both in phlegmonous gastritis and in acute pancreatitis. Abdominal puncture after the onset of peritonitis would exclude acute pancreatitis. With the abdomen opened, the condition has been recognized in the acute fulminating type by a number of observers. On the other hand, it has been mistaken for a neoplasm in chronic cases, and only upon examination of the resected specimen has the actual diagnosis been made. Aspiration of pus from the thickened gastric wall with a fine needle has been of diagnostic aid a number of times.

The average duration of the disease is one or two weeks, but several deaths have occurred within a few hours of onset. The mortality is 92 per cent. (Sundberg).

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Regarding surgical efforts to control this condition, it may be noted that success has been reported following simple drainage down to the gastric peritoneum, gastrostomy, and gastro-enterostomy; but these cases may be classed as examples of spontaneous recovery. There have been eight successful resections if we include Cases IV and V of Bircher for so-called gastritis putrida, which he maintained is a beginning stage of phlegmonous gastritis. The successful cases of Koenig (one, 1911) and Dahlgren (two, 1918) were of long standing and afebrile; and the pre-operative diagnosis was carcinoma. Zoeffel's (1913) patient was ill for six days; there was no fever; the pulse was 64, and the pre-operative diagnosis was slow perforation of a gastric ulcer. Orator (1926) operated for acute perforation of a gastric ulcer on the greater curvature, 19 cm. from the pylorus, around which was an area of circumscribed phlegmonous gastritis the size of a saucer. The two successful resections of Bircher for gastritis putrida were done on chronic cases with pre-operative diagnoses of pyloric stenosis. Novak (1919) successfully performed pylorotomy for a large submucous abscess.

The recent important contribution of Orator, from Von Haberer's clinic, draws attention to phlegmonous gastritis of the stomach as a post-operative complication. Four cases are reported. The first followed gastro-enterostomy for an inoperable carcinoma of the pylorus in a young woman. The second case was that of a man of twenty-nine. Gastro-enterostomy for duodenal ulcer had been done in 1919; jejunostomy for gastrojejunal ulcer with dense extensive adhesions in 1921; and subtotal gastric resection for gastrojejunal ulcer in 1922. There followed a phlegmonous infiltration of the submucosa around the anastomosis which involved the seromuscularis, causing a fatal peritonitis. (The total acidity varied from 62 to 74 in this case.) The third case followed resection (Billroth II) for a chronic ulcer diagnosed as carcinoma.<sup>5</sup> The fourth (Orator's own) was that of a man of forty, on whom a Billroth I resection for duodenal ulcer was done. The patient died on the fifth day with signs of gastric retention. Autopsy showed a greatly dilated stomach; there was no leak at the suture line and no peritonitis. The duodenum and jejunum were dilated up to a point 20 cm. beyond the duodenal-jejunal flexure. Grossly, there was marked swelling of the gastric wall; but only on microscopical examination was it ascertained that a typical phlegmonous gastritis existed. Orator points out that such post-operative inflammatory changes (of a less severe character) may occur more often than one would imagine. Moreover, it is possible that such inflammatory reactions confined to the region of a gastro-enterostomy opening may constitute a predisposing factor for subsequent development of peptic ulcers in this locality. Therefore, he advises routine microscopical examination of stomach tissue from those dying with the symptoms of persistent gastric dilatation, especially when peritonitis is absent.

In every large series of gastric carcinomata there are reports of patients who remained well years after palliative operations. It has been noted above

<sup>5</sup> These three cases occurred at Von Eiselsberg's clinic.

that the pre-operative diagnosis in the cases of Koenig and Dahlgren was tumor; and that only after resection was the true condition recognized. Orator cites the case of a man of sixty-three with an apparently inoperable carcinoma growing to the anterior abdominal wall, arising from the lesser curvature with involved lymph-nodes reaching to the cardia, for which gastro-enterostomy with entero-anastomosis was performed. Seven years later the patient reported himself in good health.

The extensive inflammatory changes noted in linitis plastica, which often are extremely difficult to distinguish from scirrhus carcinomatous involvement, may represent the final stage of a subacute diffuse phlegmon of the stomach.

Lastly, among a large series of resected stomachs Orator found four cases of hour-glass contracture, in which submucous cicatricial changes extended far beyond the customary distance of involvement around ulcers—conceivably the end-stages of healed phlegmons.

The case of Stapelmohr (40 in the appended table) seems to prove this point. A woman of forty-eight years was operated on eleven days after the onset of symptoms. A phlegmonous gastritis was found, the inflammation involving the omentum, transverse colon, mesocolon, and gastrocolic ligament. Pus aspirated with a fine needle from the gastric wall showed streptococcus and *B. subtilis*. Five years later examination of the patient, who was then in perfect health, showed absence of free hydrochloric acid and an hour-glass contraction of the lesser curvature.

From the foregoing evidence one must conclude with Sundberg and Orator that there are many cases of phlegmonous gastritis which recover and are not diagnosed as such.

In 1919, Sundberg published a most comprehensive monograph which included a review of 215 cases. In addition to these, the author has been able to collect 48. Of this number, 5 cases were found among 5200 autopsies at Mount Sinai Hospital. The material from one case has previously been demonstrated and appears in the literature. The four others are now published for the first time. A surgical summary of these 263 cases is appended. In passing, it may be mentioned that among 1200 autopsies at the Lenox Hill Hospital no example of phlegmonous gastritis was encountered.

The five case histories and autopsy reports from Mount Sinai Hospital follow in brief:

**CASE I.—Phlegmonous Gastritis; Ulcer; Erysipelas.**—Solomon W., fifty-two years, admitted to the medical side of Mount Sinai Hospital, July 8, 1909. Previous history was negative except that the patient had been in the habit of taking two or three whiskies daily before meals. There was also a history of erysipelas of the leg five weeks before admission.

The present illness began five days before admission, with sharp epigastric pain, frequent vomiting, chilly sensations, but no actual chill, and high fever. The patient was markedly prostrated, but after three days felt better and got out of bed, weak but comfortable. The pain returned twelve hours before admission, with fever, marked prostration, and dyspnea. The hands and feet were blue. There was a diffuse erythema over the entire body.

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Physical examination showed an almost moribund man, with marked dyspnoea and cyanosis; the pulse was rapid and weak. In the upper abdomen there was a firm, exceedingly tender, smooth mass, filling the entire epigastrium. The abdomen was moderately distended, but there was no free fluid. The legs showed healed ulcers, with irregular, well-defined, dull bluish areas around them. The patient died two hours after admission.

Autopsy No. 1802. Serous peritonitis. Lower end of œsophagus involved (4 cm. from cardia). Entire stomach wall thickened and œdematous. Small ulcer on greater curvature, 5 cm. from pylorus. Duodenum normal.

Microscopical examination: Acute suppuration of all coats of œsophagus and stomach, except mucous membrane, which was slightly involved.

Culture from submucosa of stomach showed streptococci. Spreads from involved areas of leg and thigh after long search showed single chain Gram-positive cocci.

CASE II.—*Phlegmonous Gastritis; Peptic Ulcer; Gastro-enterostomy*.—Clara S., single, twenty-seven years, admitted to Mount Sinai Hospital (service of Dr. Alfred Meyer), June 29, 1913. No previous history of gastric trouble.

Six days before admission the patient suffered from headache and fever, no chills. For the first three days she vomited three or four times daily, on the fourth day vomiting was incessant. The vomitus was foul smelling and dark green; no blood was present at any time. There was no pain and no jaundice.

Physical examination on admission showed abdomen lax. There was slight tenderness over gall-bladder. Meltzer test positive. Rest of examination was negative. The temperature on admission was 104. Blood count gave white cells, 20,000; polymorphonuclears, 81 per cent. The temperature varied from 100 to 105 daily.

On July 3 the patient was seen by Dr. A. V. Moschcowitz, who made the diagnosis of probable appendicitis, with possible complicating pylephlebitis, and advised operation. The patient was transferred to the service of Dr. A. G. Gerster. The white blood-cells then were 22,900; polymorphonuclears, 87 per cent.

At operation the same day (Doctor Moschcowitz) the stomach was found matted to the duodenum with yellowish-green fibrin, which extended along the greater curvature towards the cardia. The stomach and duodenum were markedly thickened, œdematous, and friable. A posterior gastrojejunostomy was established, with local drainage. The patient died at 1 P.M., July 4.

Autopsy No. 2371. Plastic peritonitis over upper abdomen. Gastro-enterostomy. Pyloric ulcer. The submucosa of entire pyloric end of stomach infiltrated with purulent exudate. Several abscesses surrounding ulcer.

Cultures showed streptococci.

CASE III.—*Phlegmonous Gastritis; Pyloric Ulcer; Healed Duodenal Ulcer*.—Jacob K., forty-eight years, admitted to Mount Sinai Hospital (service of Dr. A. A. Brill), July 19, 1915. Previous history was negative. Present illness began six days before admission when transient frontal headache developed. Two days later, headache recurred, and there was sudden onset of severe epigastric pain, with an attack of vomiting. Pain continued. The patient vomited three times two nights ago. There had been no bowel movement. The night before admission the stomach tube was passed, but there was no return.

Physical examination on admission showed a moribund man, with signs of pulmonary œdema and peritonitis. The temperature was 103.6. The patient died three hours after admission.

Autopsy No. 2544. Sanguino-purulent fluid in peritoneum, containing streptococci. Phlegmonous gastritis of entire stomach, involving all walls, especially the submucosa and mucosa. Old ulcer at pylorus; healed ulcer of duodenum.

CASE IV.—(Same as Case No. 14 of summary.)—*Phlegmonous Gastritis*.—Nathan P., sixty-five years, admitted to Mount Sinai Hospital (service of Dr. A. V. Moschcowitz), May 14, 1917, at 11.30 P.M. Previous history negative.

TABLE II.  
Summary of 48 Cases of Phlegmonous Gastritis Collected Since Sundberg's Series of 215 in 1919.

Case No.	Sex	Age	Occupation	Duration of illness previous to adm.	History and pre-operative diagnosis	Operative procedure and findings	Result	Autopsy or pathological findings	Bacteriology	Author
1	M	51		3 days	Epigastric pain, vomiting, fever. Profoundly ill, 1 yr. before had abdominal pain, vomiting, tarry stool, lasting 1 week		Death, 1 day	Cirrhosis of liver associated with diffuse phlegmonous gastritis	Hemolytic streptococci	Anderson.
2	M	50		2 weeks, gastric distress	Diagnosis: Carcinomatous pyloric stenosis	Resection	Death, 4th day post-op.	Bilateral pneumonia. No peritonitis. Resected specimen showed carcinoma and circumscribed phlegmonous gastritis		Bardy.
3	F		Servant	2 days	Acute abdominal symptoms, increasing severity. Diagnosis: acute appendicitis, acute pancreatitis, or perforated gastric ulcer	Bilroth II resection of $\frac{3}{4}$ of stomach. Uneventful convalescence except for light grippe pneumonia during 2d week	Death 1 mo. later from ruptured splenic varix	Edema of gastric wall. Ruptured varix of splenic vein. Exsanguination from abdominal hemorrhage. Resected part of stomach—oedema, causing thickening of 8-10 cm.	No bacteria demonstrated	Bircher. (Case No. 2). (Case No. 14). (Case No. 15). (Case No. 16). (Case No. 17). (Case No. 18). (Case No. 19). (Case No. 20). (Case No. 21). (Case No. 22). (Case No. 23). (Case No. 24). (Case No. 25). (Case No. 26). (Case No. 27). (Case No. 28). (Case No. 29). (Case No. 30). (Case No. 31). (Case No. 32). (Case No. 33). (Case No. 34). (Case No. 35). (Case No. 36). (Case No. 37). (Case No. 38). (Case No. 39). (Case No. 40). (Case No. 41). (Case No. 42). (Case No. 43). (Case No. 44). (Case No. 45). (Case No. 46). (Case No. 47). (Case No. 48).
4	F		Servant		Admitted to hospital moribund. Staphylococemia sepsis; osteomyelitis of tibia		Death	Osteomyelitis of tibia; staphylococemia; abscess of stom. wall; purulent thrombosis of coeliac artery	Staphylococci	Bircher Case No. 3.
5	F		Peasant	Several yrs. intermittent gastric distress after heavy labor in fields 1 mo. aggravated symptoms.	Emaciated woman with palpable rt. kidney and abdomen. Free HCl 24. Total HCl 52. Pyloric stenosis in X-ray picture	Ulcer on greater curvature with area of infiltration 5-6 cm. in diam.; intramuscular tumor at pylorus. Bilroth I resection, 9-10 cm. wide	Recovery	Specimen resected: infiltrated lymph-node; leiomyoma; peptic ulcer, suppurative gastritis	Not stated	Bircher Case No. 4.
6	M	Not given. Born in 1864		1 mo. gastric disturbances	Stomach dilated; left ing. hernia. Free HCl 57. Total HCl 95. Pyloric stenosis in X-ray picture	Entire pyloric region infiltrated injected and oedematous; lymph-nodes enlarged. Pylorotomy	Recovery	Specimen resected: suppurative gastritis	Not stated	Bircher Case No. 5.



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7	F	34	7 days previous tonsillitis for 2 days	1st day in hospital some epigastric pain; 3rd day severe pain, vomiting, fever, continued till 5th day. Diagnosis: acute cholecystitis. Operation	Gastrostomy. Phlegmonous gastritis of pylorus. 2 inches broad	Operative recovery, 12th day saphenous phlebitis. 15th day sharp pain in left chest, then gradual improvement till 28th day, when fatal pulmonary embolism	No autopsy	Cultures taken but not reported	Brooks and Clinton.
8	M	50	6 weeks	Pain and nausea 1/2 hr. after meals. Loss of weight. X-ray showed moderate pyloric stenosis. 1 day transient fever. Operation following day. Diagnosis: Carcinoma of pylorus	Subtotal gastrectomy. Carcinoma of pylorus. Billroth II (Polya-Reichel)	Death 1 day post-op.	Specimen of resected stomach showed carcinoma of pylorus with phlegmonous gastritis surrounding it. Autopsy: no metastatic deposits. Streptococci in heart blood	Hemolytic streptococci	Bumm, R.
9	M	52	40 days	Apparently adm. shortly before death		Death	Carcinoma of cardia, with localized phlegmonous gastritis. Sepsis		Businco (autopsy report).
10	F	50		Erysipelas following operation on lachrymal sac, 7 days prev. Convalescing until few days before death. Rise in temp. malaise shortly before death, repeated vomiting, pus in vomitus		Death 22 days after operation	No autopsy	Streptococci	Cange and Michéleau.
11	M	50		Epigastric pain and vomiting. No fever, rigidity or distention		Death less than 48 hrs. from onset	Phlegmonous gastritis of entire organ; no peritonitis	Streptococci	Eurich and Phillips.
12	M	58	2 days	Sudden onset 11 days after oper. for double inguinal hernia. Symptoms of upper abdominal peritonitis	Laparotomy drained around stomach and to pelvis. Phlegmonous gastritis and peritonitis	Death 8 hours after operation; 4 days after onset of symptoms	Phlegmonous gastritis	Streptococci	Fink.
13	F	22				Death from purperal sepsis	Phlegmonous gastritis, part of a general sepsis		Fahmy.
14	M	65	2 days	Diffuse peritonitis following perforated gastric ulcer	Laparotomy and drainage for phlegmonous gastritis and purulent peritonitis.	Death 24 hrs. after operation	Pyloric 2/3 of stomach involved. No ulcer; peritonitis	Pneumococci	Gerster (See text Case IV).
15	M	20	8 mos.	Epigastric tumor	Circumscribed phlegmonous gastritis. Pylorotomy	Operative recovery. Death 4 wks. later from secondary perforation of stom.	Not obtained. Resected specimen showed phlegmonous gastritis		Guibal.

TABLE II.—Continued.  
Summary of 48 Cases of Phlegmonous Gastritis Collected Since Sundberg's Series of 215 in 1919.

Case No.	Sex	Age	Occupation	Duration of illness previous to adm.	History and pre-operative diagnosis	Operative procedure and findings	Result	Autopsy or pathological findings	Bacteriology	Author
16	M	43			Alcoholic. Epigastric pain, vomiting, diarrhoea, moderate fever		Death in 2 days	Phlegmon of entire stomach No ulcer		Hickel, P.
17	M	37		Acute illness, brief duration		Abscess of stomach wall in pyloric region, drained	Death on 3d day	Phlegmonous gastritis. Peritonitis		Kister.
18	M	55	Metal polisher	12 wks. dull abdominal pain	Free HCl O. 4th day slight jaundice, gradually declined. Few days before death, Deiminger's symptom noted		Death 49 days after adm.	Diffuse phlegmonous gastritis associated with cholelithiasis	Streptococci	Lawrence, J. S. (Case No. 1.)
19	M	52	Laborer	3 mos. gastric disturbances	Gastric analysis normal except for stasis. Pre-operative diagnosis: Gastric carcinoma	Ulcer of lesser curvature. Billroth II. Pt. did well for 4 days; then worse	Death 7 days after operation	Post-operative phlegmonous gastritis; diffuse peritonitis	Streptococci	(Case No. 2.)
20	M	63	Laborer	6 days sore throat	Chill, incessant vomiting, epigastric pain, fever, peritonitis	Laparotomy. Stomach covered with fibrin. Drainage	Death in 24 hrs.	Phlegmonous gastritis; 2/3ds stomach involved; wall 1 inch thick. Fibrinous peritonitis	Streptococci in stained sections	Lehnhoff.
21	M	17			Suddenly ill a few hours after eating pork. Collapse. Epigastric pain, vomiting		Death 38 hrs. from onset	Typical phlegmonous gastritis; no lesion of mucosa		Moynihan.
22	F	60		1 day	Sudden onset intense abdominal pain and vomiting. Diagnosis lay between perforated ulcer, pancreatitis, and acute cholecystitis	Diffuse phlegmon of entire stomach. No peritonitis	Death 4th day from onset of symptoms	Diffus phlegmonous gastritis; diffuse peritonitis	Streptococcus brevis	MacAuley.
23	F	19		3 yrs. gastric disturbances worse last 6 mos.; sudden onset, 2 days	Diagnosis: cholecystitis. Operation 7 days after acute onset	Resection. Billroth II. Balfour-Polya	Recovery	Large submucous abscess of pyloric region; overlying mucosa intact	No report	Novak.

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24	M	29	4 yrs. gastric symptoms	1919, gastro-enterostomy for duodenal ulcer; 1921, jejunostomy for gastrojejunal ulcer with dense adhesions 1922, subtotal gastric resection for gastrojejunal ulcer	Billroth II	Death on 5th day	Post-operative phlegmonous gastritis around anastomosis in submucosa; peritonitis (Eiselsberg clinic)	Orator, V. Case No. 1.
25	F	45	9 mos.	Pain, vomiting, marked loss of weight; palpable tumor. Free HCl 0. Total acid, 26 antrum. Pre-op. diagnosis: tumor?	Billroth II for ulcer of lesser curvature, nearer pylorus than cardia	Death not stated but is cited as 2d case of post-op. phlegmonous gastritis	Resected specimen showed diphtheritic ulcer and phlegmonous gastritis involving all layers. (Eiselsberg clinic)	Case No. 2.
26	M	25	3 weeks prodromal symptoms 1 day acute symptoms	Sudden onset of epigastric pain while lifting a heavy object. Adm. with typical symptoms of perforated gastric ulcer. X-ray showed air under both sides of diaphragm	Free air in peritoneal cavity. Phlegmon of anterior surface of body of stomach, with perforation at centre. Billroth II subtotal resection	Marked post-op. acidosis controlled by glucose and insulin. Recovery	Resected specimen: small perforated callous ulcer on greater curvature; 19 cm. from pylorus; area of phlegmonous gastritis, size of a saucer around ulcer	Case No. 3.
27	M	40			Billroth I for duodenal ulcer	Death on 5th day from gastric retention	Suture line intact. Stomach dilated. No peritonitis. Microscopically, <i>phlegmonous gastritis around anastomosis</i>	Case No. 4.
28	F	60	Long history of indigestion	Diagnosis on adm. Acute perforated gastric ulcer	Anterior gastro-enterostomy. A b d o m e n drained. Phlegmonous gastritis	Death less than 24 h post-op.	Phlegmonous gastritis	Owen, D. R. Case No. 1. (Autopsy report).
29	M			Diagnosis: acute perforated gastric ulcer. Profound prostration	Phlegmonous gastritis; diffuse peritonitis. Drainage, retrovesical pouch. Diagnosed as phlegmonous gastritis at operation	Death shortly after operation	Phlegmonous gastritis	Case No. 2 (Autopsy report).
30	M		Soldier		No operation	Death	Bronchopneumonia. Diffuse phlegmonous gastritis (infection of corrosive lesions caused by poison gas)	Pech Case No. 1.
31	M	39		In hospital 1 mo., when sudden onset	No operation	Death	Pyloric carcinoma with associated circumscribed phlegmonous gastritis	Case No. 2.
32	F	56	Long history of indigestion	11 days of increased epigastric pain, fever, leucocytosis	Stomach acutely infected and thickened in pyloric half, especially post. wall. Stomach opened. Large ulcer of post. wall. Billroth I. Duodenum very long	Death 17 days post-op. Sloughing. Secondary hemorrhage	Resected specimen showed ulcerated carcinoma; suppurative gastritis. Apparently no autopsy	Rixford, E. Case No. 1.

TABLE II.—Continued.  
Summary of 48 Cases of Phlegmonous Gastritis Collected Since Sundberg's Series of 215 in 1919.

Case No.	Sex	Age	Occupation	Duration of illness previous to adm.	History and pre-operative diagnosis	Operative procedure and findings	Result	Autopsy or pathological findings	Bacteriology	Author
33	M	54			Alcoholic 1 mo. gastric symptoms; worse for past week; much worse past 2 days. Diagnosis: acute gastric ulcer with peritonitis	Indurated inflamed area, 6 cm. in diam. Aspiration of this area revealed pus. Billroth II. resection of pyloric half of stomach	Death 4 hours. post-op.	Phlegmonous gastritis	Streptococci	Case No. 2.
34	F	40	Domestic	Sore throat and cold for 6 days	At noon sudden epigastric pain, etc. Diagnosis lay between basal pneumonia, acute pancreatitis, gastric phlegmon	Entire stomach involved, thickened, red, inert. Multiple drains	Death 24 hrs. post-op.	Phlegmonous gastritis; mucosa intact.	Streptococci	Case No. 3.
35	F	37		2 days	Epigastric pain, fever, vomiting, prostration. Diagnosis: perforated ulcer	Billroth II resection	Death 2 days after onset	Carcinoma associated with phlegmonous gastritis	Streptococci	Sandelin, Case No. 1.
36	F	44		1 day	Peritonitis of unknown origin		Death 3 days after onset	Phlegmonous gastritis	Streptococci	Case No. 2.
37	F	44		5 days	"Fatal peritonitis of short duration—"			Autopsy demonstration. Pyloric region mainly involved by typical phlegmonous gastritis	Streptococci	Schoon.
38	M	39		7 days	Far-gone peritonitis	No operation	Death	Phlegmonous gastritis	Streptococci	Secchi.
39	M	29	Colored laborer	1 day	1 mo. vague abdominal pains. Diagnosis: perforated gastric ulcer	Laparotomy with drainage, gastrostomy stomach, achred, thick, and boggy	Death 28 hrs. after operation	Peritonitis; phlegmonous gastritis; many minute perforations	Streptococci	Shatara.
40	F	48		Gastric symptoms for some time. 2 days, epigastric pain and fever	Pre-op. diagnosis: infected pancreatic cyst	Pain subsided, hard epigastric mass felt as abdominal rigidity decreased. Operation on 10th day. Phlegmonous gastritis with inflammatory thickening of omentum, transverse colon, mesocolon, and gastrocolic ligament	Recovery. 5 yrs. later entirely well. Free HCl = 0. X-ray showed hour-glass contraction on lesser curvature, one finger's breadth wide	Aspirated pus from stomach wall showed streptococcus and B. subtilis		V. Stapel-mohr.

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41	F	40	Of labor- ing class	8 days dys- phagia, 2 days ago sudden onset	Epigastric pain, repeated vomiting, vomitus bloody; fever. Diagnosis: perito- nitis	Emergency operation. Phlegmonous gastritis and peritonitis, tamponade	Death 9 hrs. post-op.	Phlegmons of oesophagus, stomach, pyloric half; dif- fuse purulent peritonitis	Stöhr, Case No. 1.
42	F	74	Of labor- ing class (insane)	3 days	2 days after adm. sudden onset of peritonitis	Diffuse peritonitis. Phlegmonous gastritis. Billroth II resection of pyloric $\frac{2}{3}$ ds	Death 2 days post-op.	Peritonitis. Suture lines in- tact. Resected specimen showed phlegmonous gas- tritis; in pyloric end at cen- ter of maximal induration was a needle penetrating stomach wall	Case No. 2.
43	M	51	Sailor	2 days	Alcoholic. Acute onset epi- gastric pain, tenderness, and vomiting. Diagnosis: ulcer or pancreatitis	Gastrostomy; condition recognized at opera- tion	Death 3d day post-op.	Phlegmonous gastritis of py- loric region; peritonitis	Westbrook.
44	M	34		6 days	Gastric disturbance as child and again of late. Sudden onset epigastric pain, nau- sea, no vomiting. Phys. exam. negative, except for epigastric rigidity and ten- derness. No fever. Pulse 64. Diagnosis: slowly per- forating gastric ulcer	Immediate operation. small abscess sur- rounded by inflamed omentum. Tumor on greater curvature, size of small apple. Billroth II. Krönlein- Mikulicz resection with drainage	Recovery	Resected specimen: tumor projected into gastric lumen like a hemisphere covered by intact mucous mem- brane. On section, showed necrotic tissue infiltrated with hemorrhages	Zoepffel.
45	M	52	Carpenter	5 days	Erysipelas 5 weeks before admission. Moribund	No operation	Death 2 hrs. af- ter adm.	Entire stomach involved by phlegmon. Small ulcer at greater curvature, 5 cm. from pylorus. Serous peri- tonitis	See text, Case I.
46	F	27		6 days	Headache, chills, vomiting, no pain in abdomen. 4 days after adm. transferred to surgical side	Operation (Dr. A. V. M.) phlegmonous gastritis of pyloric half of stomach. Gastro-enter- ostomy	Death 20 hrs. after operation	Phlegmonous gastritis; py- loric ulcer; abscess of gas- tric wall near ulcer	See text, Case II.
47	M	48		6 days	Frontal headache, 4 days ago, epigastric pain; some vomiting; fever. Moribund on adm.; signs of pulmo- nary oedema and perito- nitis		Death 3 hrs. af- ter adm.	Phlegmonous gastritis of en- tire stomach old ulcer at pylorus; healed duodenal ulcer	See text, Case III. 3.
48	F	40		2 days	Chills, fever, vomiting, epi- gastric pain. Provisional diagnosis: pancreatitis. Ab- dominal puncture showed streptococci. Pancreatitis excluded (Neuhof)		Death 2 days af- ter adm.	Phlegmonous gastritis of en- tire stomach involving be- ginning of duodenum. No ulcer	See text, Case V. 5.



Present illness began two days before admission when the patient suffered from diffuse abdominal cramps, localized more to the right half of the abdomen. He had vomited several times; there had been no bowel movement for the past two days.

Physical examination on admission showed an old man, acutely ill. The abdomen was tense and rigid, the tenderness being most marked in the upper abdomen. Rebound tenderness throughout. Pre-operative diagnosis was diffuse peritonitis, probably appendicitis or perforated gastric ulcer.

At operation (the author) on May 15, at 12.50 A.M., revealed a diffuse purulent peritonitis with a sparse amount of greenish purulent exudate in all parts of the abdominal cavity. The pyloric portion of the stomach was markedly injected and thickened, in contrast to the duodenum and upper part of the body of the stomach. There were flakes of fibrin along the lesser curvature. All lymph-nodes in the abdomen were enlarged. No fat necrosis was present. The rest of the abdominal organs—gall-bladder, appendix, large intestine, etc.—were negative. The pancreas was inspected through unchanged lesser omentum. Drainage was instituted, and the wound closed. Diagnosis: Phlegmonous gastritis with general peritonitis. The patient did not react well, and died twenty-four hours later.

Cultures showed pneumococcus.

Autopsy No. 2891. Acute phlegmonous gastritis. Fibrino-purulent peritonitis. Pyloric two-thirds of stomach involved; wall 2 cm. thick, due to swelling of mucosa and submucosa. In antrum there were two large necrotic patches of mucosa, 3 to 4 cm. square. No ulcers. Duodenum and œsophagus normal.

Microscopical examination: Throughout entire wall of greatly thickened stomach there was tremendous œdema and purulent infiltration. Great number of veins filled with blood-platelet thrombi. Gram-Weigert stain showed cocci throughout section, mainly lanceolate in shape.

CASE V.—*Phlegmonous Gastritis*.—Susie J., obese negress, forty years, admitted to Mount Sinai Hospital (service of Dr. C. A. Elsberg), February 11, 1923, with history of generalized abdominal pain, vomiting, fever of 104, and chills for the past two days. No antecedent history.

Physical examination on admission showed general abdominal rigidity and tenderness; no masses; no fluid wave. The provisional diagnosis of acute pancreatitis (Dr. H. Neuhoof) was made. At 10 P.M. the same day the blood count was: White cells, 9000; polymorphonuclears, 78 per cent. The next day the patient was delirious and the high fever persisted. Abdominal puncture (Dr. Ira Cohen) yielded sero-purulent fluid, in which hæmolytic streptococci were found. The patient died at 1.45 P.M.

Autopsy No. 4191. Phlegmonous gastritis involving the stomach wall from the cardia to the pylorus and the first few centimetres of the duodenum was found, the process being most marked in the antrum. Localized perigastric abscess. No ulcers. Luetic aortitis.

TABLE I.  
*Surgical Summary of 263 Cases.*

	Recoveries	Deaths
Exploratory laparotomy with drainage .....	2	23
Gastrostomy .....	0	4
Gastro-enterostomy .....	2	2
Jejunostomy .....	0	1
Resections .....	8	10
Drainage of abscess .....	1	1
Post-operative phlegmonous gastritis .....	0	5

## PHLEGMONOUS GASTRITIS

### CONCLUSIONS

1. Phlegmonous gastritis is a rare condition, the varieties and pathogenesis of which are becoming more clearly recognized as material accumulates.

2. It may be assumed that there are:

a. Mild cases in which recovery may occur without the condition being recognized;

b. Fulminant types, ending in death within a few hours;

c. Acute cases, running a course to two or three weeks, usually with a fatal outcome, but occasionally undergoing spontaneous recovery with more or less protracted convalescence;<sup>6</sup>

d. Subacute, chronic forms which may simulate neoplasms, the less extensive types of which may lead to cicatricial changes in the gastric wall, depending on their extent and location.

3. Cures reported following palliative surgery, such as local drainage or gastro-enterostomy, may properly be considered as spontaneous recoveries.

4. Resection is the operation of choice when feasible. It gives a higher mortality in recent cases than in those which have lasted for some time before reaching the surgeon.

5. Post-operative phlegmonous gastritis is probably of more frequent occurrence than is realized, and hence it is advisable to make microscopical examinations of tissues from the region of anastomoses in all cases coming to autopsy.

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<sup>6</sup> The abscess cases fall in this group.

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## BENIGN HYPERTROPHY OF THE STOMACH AND LINITIS PLASTICA \*

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THE question of chronic diffuse thickening of the walls of the stomach has interested pathologists and surgeons for many years.

There is a considerable literature on the subject, but owing to the inherent difficulties in the way of an exact pathological diagnosis in these cases and the rarity of their occurrence, there has been, and to a certain extent still is, a decided divergence of opinion as to their classification and as to the interpretation of their pathology. A number of terms have been used to designate the same condition, and to make the confusion worse a number of essentially different pathological processes, on account of their superficial similarity, have been given the same name and treated as one disease.

This diffuse induration or hypertrophy—diffuse to differentiate it from the local induration of benign or malignant ulcer—may be general or confined to a portion of the stomach. If the former, it may be accompanied by a great diminution in the size of the organ, and the condition generally known as leather bottle stomach or linitis plastica is present.

In former days this was usually discovered unexpectedly by the surgeon on opening the abdomen or more frequently by the pathologist in the course of an autopsy. Now it should be recognized by the röntgenologist. The more local type, however, which may or may not be an earlier stage of the general type, still presents difficulties in diagnosis even with the help of the Röntgen-ray.

To begin with it is most often seen in the pyloric portion of the stomach where carcinoma is so frequently found. The symptoms correspond to those of carcinoma or indurated peptic ulcer. Finally the X-ray, upon which we have come to depend so largely for the diagnosis of stomach conditions, does not seem able to differentiate the various pathological conditions, which may be found here, into their true classifications.

The following two cases, which were operated upon by me at the Roosevelt Hospital, both came to the operating table with the diagnosis of carcinoma of the pylorus. Immediately upon palpating the stomach it was felt in each case that here was no ordinary carcinoma or ulcer, and in each there was great uncertainty as to the nature of the lesion and doubt as to the proper method of procedure.

CASE I.—Male, age twenty-seven years, was admitted to hospital September 9, 1924. *Past History.*—Measles as a child. Pneumonia at eighteen. Denies lues. Wassermann taken at Marine Hospital four years ago, negative. Treated for duodenal ulcer at Long Island College Hospital one year ago. Wassermann taken there also negative.

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\* Read before the New York Surgical Society, January 26, 1927.

*Present Illness.*—Began about two and one-half years ago with belching of gas and eructations of sour fluid. These symptoms became worse and about two years ago he began to have gnawing pains in the epigastrium. These pains had no relation to meals and were not relieved by taking food. The pain became worse and the attacks more frequent and then vomiting began. He was benefited by a course of treatment one year ago, but for the last two months the pain has been bad, and for the last three weeks, though he has eaten little, he has vomited almost daily. Bowels regular. No blood in stools. He feels weak and he has lost ten pounds in the last year and ten pounds the year before last.

*Physical examination* revealed the abdomen a little sunken, no masses. Liver and spleen not felt. Slight tenderness in epigastrium and a little muscle spasm. Normal

temperature. Blood counts normal. Stools negative for blood. Urine negative. Gastric test-meal showed normal amount of free hydrochloric acid and of total acids.

Röntgen-ray examination by Doctor Steiner: "There is an area in the antrum of the stomach,  $3\frac{1}{2}$  cm. proximal to the sphincter, that is lacking in pliability. There is a small six-hour residue. The plates suggest an organic change in the extreme pyloric end of the stomach. The findings are not those of an ulcer and not typically those of a growth. There may be a band of adhesions lying across the stomach at this point and crossing the defect. The probabilities are that this is an infiltrating type of new growth."

*Operation.*—September 24, 1924. The stomach was normal in size. There was a pronounced thickening of the stomach wall in the pylorus, a little proximal to its junction with the duodenum. It formed a ring about 3 cm. wide around the pylorus and it extended upward toward the cardia (more



FIG. 1.—Case I. Appearance of stomach before operation, showing the stenosis of the pylorus and the rigidity of its walls.

along the lesser curvature than the greater) for a distance of 15 cm., diminishing in degree as it extended upward. This thickening was regular in outline, smooth and with an elastic hardness. Nothing to suggest the crater of an ulcer could be felt. The pylorus was evidently partially stenosed by the thickened ring. There were a few adhesions between the pylorus and adjacent structures. The duodenum was quite adherent to the gall-bladder, which was sharply angulated by the adhesion, but otherwise normal. There was no induration along the lesser or greater curvatures and there were no enlarged lymph-nodes and no nodules in the liver.

A partial gastrectomy was done, excising about 10 cm. of the stomach. It was not possible to get entirely beyond the indurated area and the line of resection showed the thickened stomach wall, white and moist looking. The mucous membrane did not prolapse as usual over the cut edge of the stomach and in making the anastomosis it was necessary to use care to pick up enough mucosa in the suture. The stump of the duodenum was inverted and a posterior gastro-enterostomy was made, end of stomach to side of jejunum.

*Pathological examination* by Doctor White. Macroscopic: The specimen consists of a portion of the stomach still preserved in its tube-like shape. The external surface is somewhat congested and no longer glistening, but it is smooth, without elevations or



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puckered contracted portions. The stomach wall is everywhere greatly thickened, hypertrophied and oedematous. This hypertrophy is more pronounced as one approaches the pylorus. It is .5 cm. in thickness at the cut fundus and .9 cm. just proximal to the pyloric muscle. There is no infiltration of hard or indurated tissue in the wall; it is soft, tough and elastic. The thickening seems to have taken place in the submucosa and muscularis layers. The pyloric canal admits only the little finger, 7 mm. in diameter. Here the wall measures 1.4 cm. in thickness. On cutting down through the wall in different places of the stomach it is seen to be made up of a mucosa which is thrown into folds and is everywhere soft, oedematous, gray and granular without areas of ulceration or puckering. The remaining portion is soft, brown-red, homogeneous, smooth muscle tissue without infiltrated areas or nodules. On cross-section of the pyloric canal it is seen to be made up of identical architectural structure but with the muscularis layer in greater preponderance. Grossly this specimen reveals no pathology except hypertrophy of the muscularis layer of the stomach with increase toward the pylorus and some oedema of the entire mucosa and wall.

Microscopic.—All sections are alike in showing no serous coat and in showing a very thick muscular coat cut obliquely so that no definite division into the layers can be made. The muscle cells are long and of large calibre, stain well in most places and have normal nuclei. A few bundles are pale and somewhat shrivelled, giving the illusion of great proliferation of the sarcolemma cells. There is little or no infiltration of the muscularis, although in the neighborhood of the blood-vessels there are many strands of young connective-tissue cells with deep-staining nuclei. In a few spots are to be seen clumps of pale blue-staining cells with ill-defined cytoplasm, but very deeply stained nuclei. Some of these nuclei are large and vesicular with one or more nucleoli; others resemble connective-tissue nuclei. These cells suggest the sympathetic ganglion cells of Auerbach and Meissner. The submucosa is very oedematous in contrast to other layers and contains dilated blood-vessels, but no abnormal elements. The muscularis mucosa is normal where seen and in these places there is good demarcation between these layers and the proper mucosa. The mucosa shows the lower layers fairly well. The glands are simple branched tubules quite tortuous; their upper body, neck and mouth being often absent. The chief cells are high columnar or pyramidal with normal nuclei and ergostoplasm; but the parietal cells are so heavily stained as to obscure their finer structure. The glands are separated by a richly cellular and vascular stroma which is densely infiltrated with leucocytes. The latter are chiefly lymphocytes and seem to migrate up from the extensive solitary lymph follicles which are seen between the gland fundi and the muscularis mucosa. The lumen of the glands contains blue-staining mucus. The great vascularity and infiltration of mucosa, taken with oedema of submucosa and thickening of the muscular coat point to a long-standing irritative process.

This patient has been followed up carefully. He was last seen about three weeks ago, January 6, 1927, more than two years after his operation.

He is now as he says in perfect health. He eats and drinks as he pleases and has no gastric symptoms. He has regained his normal weight. The following X-ray report

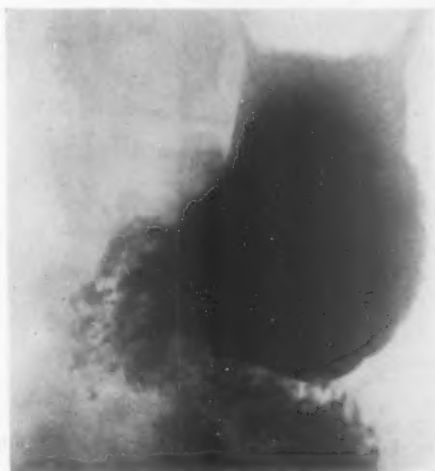


FIG. 2.—Case I. Two years after partial gastrectomy. The stoma is freely patent. There has been no extension of the disease.

## KIRBY DWIGHT

shows the present appearance of his stomach. It is interesting to note that there has been no extension of the pathological process.

"The stomach shows the characteristic deformity of resection with a freely patent stoma. The stomach is completely evacuated at six hours. The remaining segment of the stomach shows good pliability with no evidence of extending induration or recurrence."

CASE II.—Male, age thirty-two years. Admitted July 30, 1926. Chief complaint: Gnawing pain in the stomach and loss of weight. Present illness: About ten months ago the man first began to have a gnawing pain in the epigastrium radiating to the back and both sides. This was accompanied by nausea and vomiting of sour material and it usually came on about ten minutes to one hour after meals, though there seemed to be no definite regularity in this respect. He consulted his local doctor, who placed him on a diet free of fried foods and gave him soda. The soda gave relief from pain. He didn't try food for relief of pain. He continued to have the gnawing pain, nausea and vomiting for about one month and a half, when he again regained his appetite and the pain ceased until about four months ago, when the symptoms all returned as before. He has been constipated during the present illness and this condition has been relieved only by large doses of milk of magnesia and cathartics. At times he has noticed that his stools were black in color. He has lost forty pounds in weight during the past year.

*Past History.*—Usual diseases of childhood. No other diseases of any moment. No injuries. No operations. No venereal diseases. After returning from the war the patient was extremely nervous and it took him some time to adapt himself to civilian life. No history of familial diseases.

A fairly well-nourished young man, abdomen flat and soft. No tenderness or muscular spasm. No masses. Kidneys, liver and spleen not felt.

Cervical glands are palpable, but not much enlarged.

*Gastric Test Meal.*—No free hydrochloric acid. Total acidity varying from 10 to 40 in different tests. Blood Wassermann—four plus.

*Röntgenological examination* by Doctor Steiner. "Annular defect in the extreme pyloric end of the stomach in the immediate prepyloric area. This deformity has all the characteristics of a new growth, at the present time non-obstructive in character."

*Operation.*—August 14, 1926.

The stomach was diminished in size in the pyloric region. The blood-vessels on the anterior and posterior walls were closer together than usual and appeared somewhat enlarged.

The stomach was free anteriorly, but posteriorly it was slightly adherent to the transverse mesocolon.

The pylorus was greatly thickened, both the anterior and posterior walls; more marked on the posterior wall and more marked at the lesser curvature. The thickness of the wall at this point was about one centimetre. The thickening was smooth and even. It did not suggest a new growth. No crater was felt. On incision the cut edge looked white and oedematous.

The induration stopped abruptly at the pyloric ring, but extended to the left for some distance into the body of the stomach, the thickness of the stomach wall gradually decreasing to normal in the cardiac end of the stomach. There was a large superficial ulcer, about 6 cm. in diameter and involving only the mucous membrane, situated at the lesser curvature of the pylorus and extending down the anterior and posterior walls. There were also several punctate erosions of the mucous membrane proximal to it. The mucous membrane was thin, friable, and adherent to the submucosa. It was not thrown up into ridges and folds, as is normally the case, but lay perfectly flat. In making the anastomosis it had a tendency to retract instead of prolapse.

There were a number of enlarged lymph-nodes along the greater and lesser curvature.

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These had the feel of hyperplasia and not of carcinoma. There were no nodules in the liver.

A partial gastrectomy was done with posterior Polya. The induration extended so far toward the cardia that it was not possible to resect all of it, so the anastomosis was through pathological tissue.

*Pathological examination by Doctor Lester.*

**Macroscopic.**—The specimen consists of the distal portion of the stomach. It measures 9 cm. by 6 cm. The wall is thickened, measuring 1 cm. at the lesser curvature. On the lesser curvature is a shallow irregular ulcer measuring 4 cm. by 2 cm. The submucosa is very much thickened and oedematous. The muscularis is also increased in thickness.

**Microscopic.**—Sections were taken through the shallow ulcer and through the underlying musculature. The mucosa of the base of the ulcer is present, but thinned out. The surface is somewhat eroded and lying just underneath it is a considerable round-cell infiltration with a scattering of polymorphonuclear leucocytes, mostly eosinophiles and some red blood-cells. In the deeper layers of the mucosa the inflammatory infiltration is still present, but to a less degree. There are many small blood-vessels throughout the mucosa which are dilated and engorged with blood. The gastric glands, though somewhat distorted by the inflammatory process, maintain their normal arrangement for the most part. The epithelial cells are normal and show no tendency toward hyperplasia, nor invasion.

In the mucosa adjacent to its ulcer the picture is essentially the same, except that the surface is not eroded and the glands are longer. In the deeper layer there is considerable oedema. A few solitary lymph follicles are present. In the submucosa the oedema present in the deeper layers of the mucosa is much more marked. Below the ulcer the oedema is so great that fixed tissue elements are difficult to determine. In the tissue adjacent to the ulcer the oedema is likewise a prominent feature, but the fixed tissue elements are more in evidence though broken up into narrow strands by the oedema. Many capillaries and arterioles are present and distended with blood. A diffuse round-cell infiltration pervades the whole submucosa with dense collections around the arterioles. Red blood-cells are also present outside the vessels. In the muscularis the same inflammatory process exists with oedema and round-cell infiltration. Here, however, it is less acute and there is a moderate amount of fibrosis separating the musculature into bundles. Nerve fibres are abundant and in a few areas, near the serosa, ganglion cells are present. There are no atypical cells. The picture is essentially that of inflammation—subacute on the mucosal surface and shading into chronic in the deeper layers. This causes a definite thickening of the stomach wall which is further increased by hyperplasia of the tissues. There is nothing in it to suggest malignancy.

This man was last seen in December, 1926, about six months after the operation. He was then feeling perfectly well. The röntgenological report is as follows:

"There is a freely patent stomach with the meal, passing freely from the stomach into the jejunum, and we can find no morphological defect in the remaining segment of the stomach. The stomach is completely evacuated at six hours."

Fifteen or twenty years ago both of these stomachs, of different pathology as you have seen, might have been called examples of linitis plastica in an

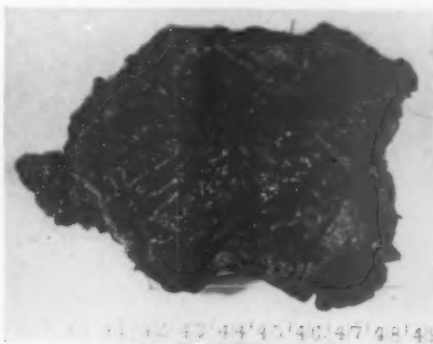


FIG. 3.—Case I. The pyloric portion of the stomach, split along the greater curvature and spread out flat. Showing the thickness of the walls and the appearance of the mucous membrane. The duodenal junction is on the left.

early stage. Many cases are recorded in the literature in which the pathology was very similar. The process was usually complete throughout the whole stomach, but nevertheless it was recognized that the disease began in the pylorus as a rule, and was most marked in that region. In fact, almost any chronic diffuse thickening of the stomach wall was called linitis plastica unless it was a very evident scirrhus carcinoma.

In an excellent article by Brissaud in 1900 is given a classification of the various processes that were thought by different writers to be linitis: New growth. Chronic inflammation. Sclerosis. Chronic œdema.

He describes the condition as follows:

"The wall of the stomach is thickened markedly. The thickening is not limited to the pylorus, it can extend to all parts of the stomach. It is not a serous or fibrinous infiltration, but the formation of a tissue not preëxisting in the stomach. A rare disease with a confused symptomatology, not cancerous. It begins in the pylorus and spreads through the stomach. There are epithelioid cells in the muscularis mucosa and submucosa."

Bensaude and Rivet give linitis as one of the forms that syphilis of the stomach may take.

Quénu thought linitis was probably malignant, but cited two other possibilities scirrhus, primary or secondary, and chronic inflammation.

Wyard classified the stomachs as either diffuse carcinoma or diffuse fibromatosis.

This confusion caused Goldschmidt to complain that linitis was a difficult subject to study from the literature as different authors approached it from the different angles of clinical course, gross pathology or microscopic study, and included carcinoma, lues, gastritis phlegmonosa, fibromatosis, etc.

He thinks that a sharp line should be drawn between those cases that are localized in the pylorus and those in which the entire stomach is involved and says that it is especially important to omit those cases which are hypertrophies of the pyloric musculature.

In this last contention he is undoubtedly right. He is probably wrong in excluding all cases where the main lesion is in the pylorus, for linitis is supposed to begin in the pylorus, and though the onset of the disease is so insidious that nearly all the cases reported have been full blown at the time of their discovery, yet there are a few cases in which the typical appearance described by Brinton is seen in a lesion confined to the pylorus.

One was a case of Quénu's (1906) which, except for the microscopic picture, is very much like the second one of my cases. The wall of the stomach in the pyloric region was very thick,  $1\frac{1}{2}$  to 2 cm. limited abruptly at the duodenal line, but shading off toward the cardia; there was a shallow ulcer. In his case the microscopic picture was one of fibrous degeneration and groups of epithelial cells. Metastases in the lymph-nodes. He did a partial gastrectomy, but the patient died a year later with local recurrence.

Monprofit, in discussing Quénu's case, said that he had had a similar one in which the microscopic examination did not show any evidences of cancer, but nevertheless the patient died a year later of a recurrence.

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There are some to-day who do not consider linitis a pathological entity. Pauchet, writing in 1924, says that it is nearly always a fibro-carcinoma, but that there are cases which are purely inflammatory, and he considers that the most frequent cause of the inflammatory type is syphilis. But he considers that syphilis of the stomach is much more common than it is supposed to be, while Hartwell thinks that most of the cases reported are not syphilis.

Faroy thinks that syphilis is the cause of the peculiar action and appearance of carcinoma in Brinton's disease.

Lewald recognizes three kinds or causes of linitis. Syphilis, carcinoma or fibromatosis, and counsels röntgenologists to keep in mind the triple possibility of linitis.

*Linitis plastica* is a name that was given by Brinton in 1854 to a rare and curious condition of the stomach. This condition or something like it had previously been seen and reported by several writers, notably Cruveilhier and Andral, but Brinton was the first to accurately describe it and give it a clinical entity. He described it, but did not know its nature. He thought it was a benign process, but was not sure. As Brissaud said of the name, "It had the merit of designating the lesion without pretending to explain its nature."

This condition was a diffuse or circumscribed increase in the connective tissue of the stomach; chiefly in the submucosa, with a resulting marked thickening in the walls of the stomach and a decrease in its capacity.

This thickening started in the pylorus and gradually extended toward the cardia, progressing faster along the lesser curvature than along the greater. It did not extend down into the duodenum, but ended abruptly at the gastroduodenal junction. Microscopically there was a great increase in the connective tissue of the gastric wall, particularly in the submucosa. The mucous membrane was intact, but at the bottom the gland crypts were surrounded by connective tissue. The muscularis mucosa was not much changed. The greatest change lay in the submucosa. It was enormously thickened by the great increase in fibrous tissue, which lay in irregular bundles and which, together with the interlacing arterioles (the seat of a marked endarteritis) penetrating into the mucosa, gave the peculiar woven effect which suggested



FIG. 4.—Case I. Photomicrograph showing the inflammatory reaction in the mucous membrane, the narrow and oedematous submucosa, and part of the muscularis.



to Brinton the name "linitis" ("rete ex lino facta"). Also, in the submucosa, interspersed in this fibrous tissue, were small atypical epithelioid cells, with deep-staining nuclei, lying either singly or in small groups.

The muscularis was increased in thickness, but the amount of actual muscle tissue might be decreased by atrophy, connective tissue being found lying between the bundles of muscle cells. The muscle cells were not destroyed or invaded. The connective-tissue bundles passed into the subserous coat and

caused the woven or knitted appearance that the stomach might have from the outside. And finally adhesions might be caused between the stomach and adjacent viscera.

The disease had an insidious onset, caused great cachexia, and it ended in death.

It was not long before pathologists arose who considered the disease cancerous. It occurred in people of the cancer age, males more than females. Gastric test-meals showed diminution or absence of hydrochloric acid. Robitansky, in 1859, was the first to espouse the cause of malignancy. He thought that those epithelioid cells in the submucosa were carcinoma cells. Others disagreed with him and maintained that they were endothelial cells or at most epithelial cells which had been split off from the gland crypts by the

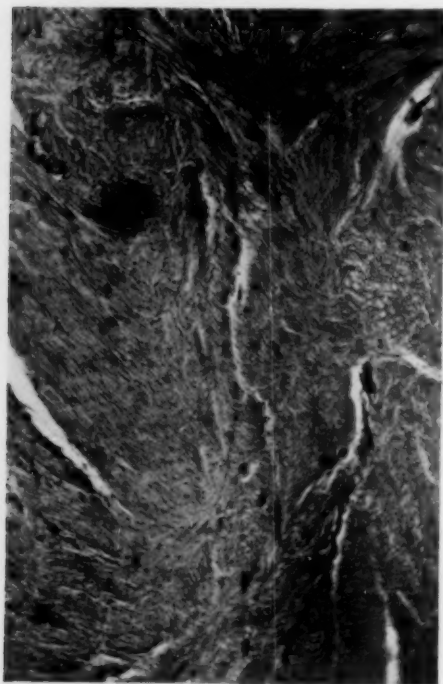


FIG. 5.—Case I. Photomicrograph showing the hypertrophy of the muscularis.

overgrowth of fibrous tissue. Thus was started a discussion which has lasted with varying fortune until the present day.

At first opinion was almost entirely in favor of the benign theory and at the beginning of the present century linitis was differentiated quite sharply from the leather bottle stomach, as the following quotations will show.

Mayo-Robson, in *Keen's Surgery*, published in 1911, calls leather bottle stomach an atrophic carcinomatous stomach and says "this condition may be simulated by cirrhosis of the stomach (gastric linitis)"—and again—"In true plastic linitis there is no evidence of new growth, the thickening being due to hypertrophy of the muscular coat and infiltration of the wall of the stomach with inflammatory exudate, which in places has been converted into fibrous tissue."

But from about 1905 on, beginning in France, the general opinion began to lean more and more toward the theory of malignancy.

Lyle, in 1911, published a most comprehensive article on the subject, in

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which he reviewed all the literature and abstracted and analyzed all the reported cases. He considered that 68 of them were benign and 58 malignant. He added a case of his own on which he did a gastro-enterostomy. The examination of a small piece of tissue taken from the stomach for analysis showed that it was benign. This patient lived for eleven years after the operation.

Lyle proved that there was such a condition as a benign diffuse fibrous thickening of the stomach wall with contraction in its size, and he considered that the name linitis plastica should be reserved for these cases and the malignant cases discarded.

In the meanwhile the cases reported in the literature grow more and more malignant. This effect was given in some cases by the assertion of the authors that they saw cancer cells in the submucosa (when the nature of those cells was the very subject in dispute) without describing them or giving any other proof of malignancy. Others dragged in obvious cases of diffuse carcinoma, with cancer infiltrating all the coats of the stomach, extending into the greater and lesser omenta and with metastases in the lymph-nodes and other organs; until the terms leather bottle stomach and linitis plastica became synonymous to some writers.

Massias and Auriat, writing in 1922, found that the great majority of writers considered linitis to be a malignant neoplasm, and that seems to be the general opinion to-day. There have been great difficulties in the way of settling this question. In the first place, as many writers, Goldschmidt and Lyle particularly, have pointed out, there have been many cases reported as linitis, which evidently were not. These were cases of almost pure muscular hypertrophy, of chronic inflammation and of just plain scar tissue following ulcers or other forms of infection, cases of ordinary carcinoma of the scirrhus type, such as have been mentioned above.

As Ewing says, the usual form of scirrhus carcinoma is easily differentiated by the diffuse thickening of all the coats, the frequent presence of metastases and especially by the microscopical evidence of round-cell, or alveolar or gelatinous carcinoma. In linitis the epithelioid cells are reduced to a minimum or largely disappear.

"If you wish to converse with me," said Voltaire, "define your terms."

It seems to the present writer that it is useless to try to reverse the present trend in definition, even if it were desirable to do so. Since the time of Brinton pathologists have used the microscopic picture of the disease, with emphasis on the atypical epithelioid cells in the submucosa, as the basis for their discussions.

Quoting Ewing again, "A diffuse scanty infiltration of large cells, with hyperchromatic nuclei, but of wholly indefinite origin."

So let us follow their example and define linitis plastica, whether complete or partial in the terms of its microscopic pathology. But even with false and doubtful cases excluded by careful and competent microscopic examination, a decision as to the malignancy of the disease would still have been difficult.

In the description of the course of the disease given some pages back, you will have noticed that its onset was insidious and that it ended in death. Most of the specimens were found at autopsy, and few cases survived after operative interference for more than a year. But the cause of death was not by metastasis as in other forms of malignancy, but by the local effect of the disease on the stomach and consequent starvation, and many of the autopsy specimens showed no metastases whatever.

In case of dispute one cannot prove that a piece of tissue found at autopsy is benign; neither in the absence of metastases can it be proved malignant.

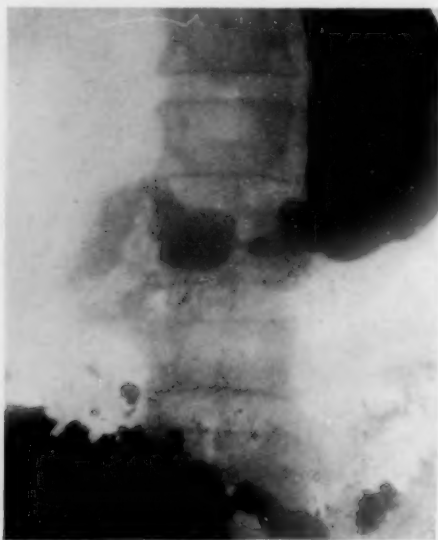


FIG. 6.—Case II. Appearance of stomach before operation, showing rigidity and filling defect in pyloric region.

It takes years of survival on the one hand, or the demonstration of metastases on the other, to constitute proof. In a few exceptional cases this proof was forthcoming—but on both sides.

Specimens have been found which showed typical linitis plastica in the stomach and metastases in the adjacent lymph-nodes, with the cells in the nodes similar to those in the stomach and the corresponding tendency toward the formation of fibrous tissue. There have been metastases in other organs as well.

On the other hand, Von Eiselsberg had a patient who lived for fifteen years after a jejunostomy. She died of cancer of the uterus.

There is Lyle's case, referred to above, who lived eleven years after a gastro-enterostomy and there are a few others.

The only conclusion that we can draw from this conflict of evidence is that either—

1. Linitis is not a pathological entity.
2. The microscopic picture of none of the surviving cases was that of a typical linitis.
3. The malignancy may be very low in some cases, so that death by metastasis takes a very long time if the nutrition of the patient is kept up.
4. Or the tumor may strangle itself in its own fibrous tissue.

As Ewing describes it, linitis "is a peculiar form of carcinoma, probably occurring in resistant subjects and originating from cells of limited growth capacity, it pursues a chronic course and tends to spontaneous regression of the tumor process, but to the death of the patient." Ewing bases his opinion that linitis is a form of carcinoma on the fact that on careful examination of a specimen, on hunting long enough, he has always been able to find the cells with mucous degeneration and signet ring nuclei, typical of gastric cancer.

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Thus defined and disregarding its interpretation, linitis plastica stands as a sort of no-man's land between the obviously malignant and the plainly benign cases of hypertrophy or induration of the stomach wall.

As to the last type, the plainly benign, what can be said as to their etiology? All the suggestions, with the one exception of malignancy, that in the past have been given to account for linitis, can be used here. Idiopathic hypertrophy of the muscle, especially in the pylorus; syphilis; chronic pyogenic inflammation; cirrhosis; fibromatosis; acute phlegmonous gastritis; chronic œdema; etc., etc.

All of these, it may be, can cause indurations of the stomach wall to be differentiated from Brinton's disease and from one another only by careful microscopical examination.

Auneau and Tassin reported cases of hypertrophic stenosis of the pylorus in the aged. Maier-Landerer reported 22 cases of hypertrophic stenosis in adults between the ages of twelve and eighty years with the average age twenty-seven years. It is interesting to note that Cruveilhier, one of the very first to call attention to this condition, called it a benign hypertrophy of the pylorus.

Wyards considers his benign cases to be examples of fibromatosis. Osler recognized a diffuse cirrhosis of the stomach due to a long-standing catarrh. Staplemohr and Nothnagel both thought that a chronic induration might result in those cases of acute phlegmonous gastritis that survive the acute stage. Pauchet, Faroy, and Bensaude and Rivet thought that syphilis was an important etiological factor. Krompecher thought that the non-malignant cases were due to a chronic inflammation and he attributed the changes in the stomach to œdema, fibrosis, muscular hypertrophy and irritation by foreign bodies.

Ewing says that a considerable group of cases reported in the literature as linitis appear to be examples of chronic gastritis with marked contraction and thickening of the whole or much of the stomach. "In these cases there appears to be a hypertrophy chiefly of the muscular coat, while the submucosa lacks the extensive overgrowth of linitis."

Under one or another of these categories we must place the two cases presented in this paper. For they do not correspond to the definition of linitis plastica and they are not obviously malignant. Moreover, as Krompecher has said, "the presence of œdema is one of the strongest points in favor of a benign process."

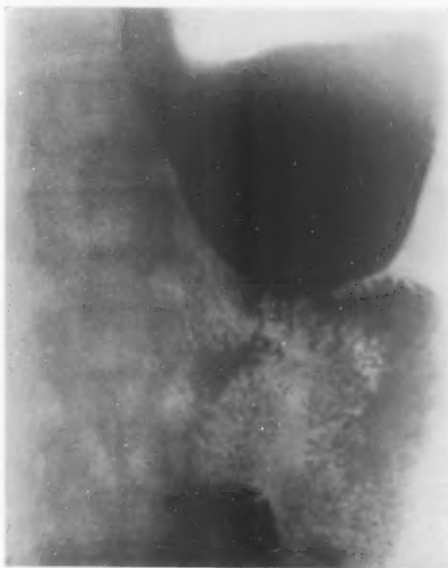


FIG. 7.—Case II. Six months after operation. Stoma freely patent. No extension of disease.

It is my opinion that they are both examples of chronic inflammation of the stomach. The reason for their different microscopic pathology I do not know.

In the first case, of course, with its ring of markedly hypertrophied muscle around the pylorus, the possibility of a hypertrophic stenosis must be considered. In the two cases of Auneau and the one of Tassin there were no signs of a chronic gastritis and there was great proliferation of the sympathetic nerve elements. Auneau considered these to be examples of myomatous hypertrophy, such as is seen in the new born. He considered the cases of



FIG. 8.—Case II. The pyloric portion of the stomach, split along the greater curvature and spread out flat. Showing the thickness of the walls, the appearance of the mucosa and the superficial ulcer. The duodenal junction is toward the left.

Chaput and of De Guy, in which a chronic gastritis was present, and those of Hartmann and of Ramond and Clément, in which ulcers were present, to be examples of hypertrophy from irritation. The more so since in the last four cases the hypertrophy showed a tendency to spread over the stomach, while in the first three it was confined to the pylorus.

In the case of Maier-Landerer no microscopical study was made, so it is difficult to draw any conclusions from them. They considered them to be cases of congenital hypertrophy appearing for the first time in adult life. Krompecher felt that they were wrong in this belief.

In my own case, pain was a prominent feature of the symptomatology. This would seem to indicate that the process was an inflammatory one, as in the hypertrophic stenosis of the new-born pain is absent.

In my second case there is a possibility of syphilis. The patient had a four-plus Wassermann. But as Hartwell so forcefully pointed out, in a paper read before this society in 1925, the presence of a positive Wassermann reaction in a patient with a lesion of the stomach does not prove that it is gastric syphilis. In this case no evidence of syphilis could be found in the slides of the stomach. It is true that syphilis may have been the cause of the inflammation. It is more than likely that the toxins of syphilis had some effect on the course of the disease, just as it has in other inflammatory processes. But that is as much as we can say in the light of our present knowledge.

In considering the operative treatment of cases such as mine, in which the major part of the lesion is in the pyloric half of the stomach, it is important to remember that even with the abdomen open and the stomach between our fingers it is impossible to determine whether the condition is a linitis plastica or one of its benign simulacra. A frozen section would be of little



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help. Lyons reports that in 25 cases of leather bottle stomach, operated on at the Mayo Clinic, specimens were removed for examination. Six cases, after careful microscopic study, were thought to be benign. All these six patients died shortly after the operation and further microscopic examination of their stomachs showed the presence of the small carcinoma cells in all of them.

In true linitis the best procedure would be a total or subtotal gastrectomy. But considering the insidious onset of that disease the chances are in favor of a benign process in those cases coming to the operating table with only partial involvement of the stomach. And it seems to me that the added risk in doing such radical surgery in the benign cases more than counter-balances the danger of an incomplete operation in the malignant ones.

I consider partial gastrectomy with a Polya anastomosis the operation of choice. In the benign cases it removes most of the disease and the main focus of irritation; and if the pathological process should continue to spread through the remainder of the stomach, there is a wide stoma which can stand considerable contraction without stenosing.

Carnot in his explanation of the symptoms in linitis, says that the pyloric valve may or may not be involved in the thickening and rigidity.

If it is not involved, it remains competent as a sphincter; the stomach wall being diseased and rigid, it does not get its normal stimulus to relax; the stomach itself can hold but a few ounces; consequently food is rejected almost as soon as eaten and the symptoms resemble those of carcinoma of the lower end of the œsophagus.

If, on the other hand, the pyloric valve is involved in the induration, it becomes incontinent. Food entering the stomach can find its way into the duodenum. The symptoms are not nearly so urgent and the patient can live without much discomfort until a stenosis begins to develop.

If after a Polya gastrectomy the induration and contraction should spread through all the rest of the stomach, the second, not the first, condition as described by Carnot would be present, for the stoma is certainly an inconti-

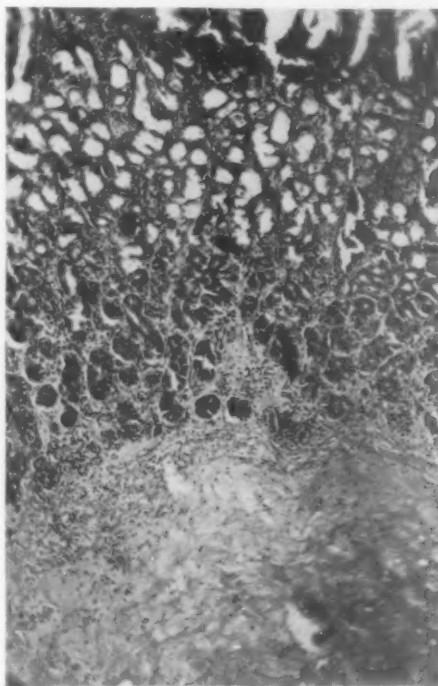


FIG. 9.—Case II. Photomicrograph of the stomach wall, showing the floor of the ulcer. There is a good deal of the mucous membrane left and it shows a marked inflammatory reaction. The fibrosis and edema of the submucosa are quite evident.

ment opening. And in addition the rigid gastric canal would be very short, the danger of stenosis would be reduced to a minimum, as it is most likely to occur in the pylorus, and the food entering the stomach could drop by gravity almost directly into the jejunum.

# SUMMARY

1. As formerly used the term *linitis plastica* designated all the conditions of hypertrophy and induration of the stomach not obviously malignant.



FIG. 10.—Case II. Photomicrograph of stomach wall adjacent to the ulcer, showing inflammatory reaction in the mucous membrane and in the submucosa.

2. As now used it refers to a group of cases, probably malignant with a definite micro-pathology, but with a disputed interpretation of that pathology. It separates the cases of evident malignancy from those that are clearly benign.

3. The benign group can be subdivided into cases of hypertrophic pyloric stenosis; fibromatosis; cirrhosis; chronic inflammation, syphilis, etc., etc.

4. The cases reported in this article are probably examples of chronic inflammation.

5. All these benign conditions may resemble *linitis plastica* and one another to such a degree that careful microscopical examination is necessary to differentiate them.

6. When the lesion is confined to the pyloric half of the stomach the X-ray picture closely resembles that of carcinoma of the pylorus, and the operation is likely to be undertaken under that diagnosis.

7. In this condition it is impossible to tell, at the time of operation, whether one is dealing with a benign or a malignant process.

8. In the opinion of the writer a partial gastrectomy with a Polya anastomosis is the operation of choice under these circumstances.

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THE EFFECT ON THE JEJUNAL MUCOSA OF  
TRANSPLANTATION TO THE LESSER  
CURVATURE OF THE STOMACH\*

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SUFFICIENT evidence has been presented to prove definitely that chemical and mechanical factors are of great importance in the production of certain experimental peptic ulcers and in the prevention of healing (Mann). The character of the lesion and its usual site of formation would suggest that the same factors are significant in the production of peptic ulcer in man although most of the experimental studies were on the jejunal ulcer. One of the most important points of evidence against the view that the chemical factor is of significance in the causation of gastrojejunal ulcer is the fact that ulcer does not form when the jejunal mucosa is transplanted with intact blood supply into the gastric wall. It would seem logical to assume that, if gastric digestion were a factor on the causation of gastrojejunal ulcer, it would occur from such transplantation, but, as a matter of fact jejunal mucosa has remained normal for almost a year after being transplanted into the anterior wall of the stomach (Mann).

The mechanics of the emptying of the stomach are such that it is highly probable that some areas of gastric mucosa are subjected to greater chemical and mechanical stress than others. The importance of this fact in regard to the usual site of ulcer formation in the stomach, the lesser curvature, has been repeatedly emphasized, especially by Aschoff, and has been substantiated experimentally by Morton. Owing probably to the ease of performing the operation, the jejunal transplant has always been placed in the anterior or posterior wall of the stomach, where peptic ulcer rarely occurs. In view of the definite knowledge that chemical and mechanical factors were of such great importance in the production of certain jejunal ulcers, it seemed desirable to repeat the previous work but to select the site where the stress of the chemical and mechanical factors was greater and where peptic ulcer usually occurs in man, the lesser curvature.

A considerable number of observations has been made on gastrojejunal ulcer since the lesion was first observed, many of which are pertinent to the etiology of the lesion. The ulcer is usually situated in the jejunum at the point where the mesentery is attached. It occurs more often after anterior than after posterior gastrojejunostomy, and the lesion is most likely to develop after certain special types of operation, such as the Y method and pyloric

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exclusion, consisting of division of the stomach at the pylorus. De Takats reported an incidence of jejunal ulcers as high as 21 per cent. after gastro-enterostomy with pyloric exclusion. Denk reviewed 309 cases of post-operative jejunal ulcer. Benign pyloric stenosis occurring with post-operative jejunal ulcer was noted in most of the male patients. In this series only two cases were noted in which the original lesion was distant from the pylorus. Balfour recently reviewed the problem of gastrojejunal ulcer. Although the incidence of gastrojejunal ulcer following gastro-enterostomy is relatively low, it is greater after duodenal than after gastric ulcer. De Takats suggests that in the future it may be possible to correlate the incidence of gastrojejunal ulcer with the degree and character of the pyloric obstruction.

A complete analysis demonstrates that certain factors are present in all those operations on the stomach that show an increased percentage of jejunal ulcers. The most important factor is the prevention of the contents of the duodenum from meeting and quickly and

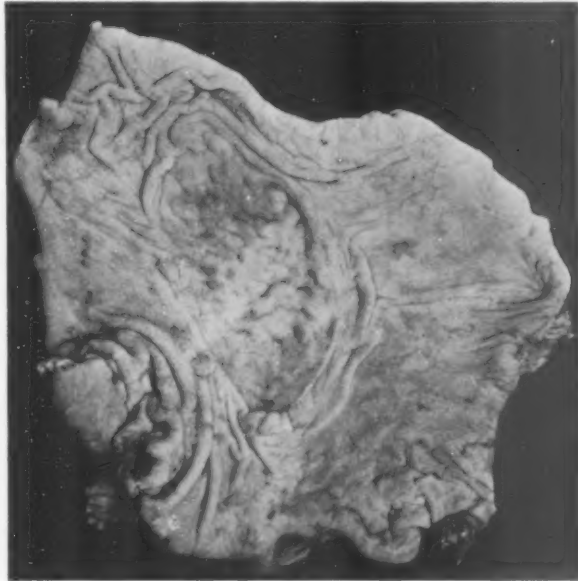


FIG. 1.—Transplant of jejunum to the lesser curvature of stomach, which remained normal for 233 days.

completely mixing with the gastric contents as they emerge from the stomach. The Y operation particularly has this defect. With pyloroplasty, gastroduodenostomy and similar types of operation, the gastric contents impinge on duodenal, not jejunal mucosa, and also it is possible for the contents to mix.

Experimental work has largely corroborated the general clinical observations. A few jejunal ulcers have been induced by diverting the duodenal contents as in some of the operations performed on man. Exalto, Bickel, Koennecke, Dott and Lim and van der Hütten induced gastrojejunal ulcer by performing gastro-enterostomy with pyloric occlusion. Mann and Williamson uniformly induced jejunal ulcer by draining the duodenal contents away from the point of emergence of the gastric contents.

Although the experiments dealing with diversion of the duodenal contents prove that a chemical factor is of great importance in the production of jejunal ulcer, those dealing with transplantation of jejunal mucosa into the gastric wall have not shown the development of ulcer when the mucosa was directly exposed to the gastric contents. Hotz has given a complete bibliography of the early work on intestinal transplants in the stomach. The



results of these experiments showed that, if the circulation of such transplants was maintained, the jejunal mucosa remained intact. The more recent work of Dragstedt and Vaughn, who transplanted duodenum, jejunum, ileum, colon, incised spleen, and kidney into the anterior wall of the stomach, also showed that digestion or the formation of ulcers in such transplants did not occur if the circulation was maintained.

These experiments in which the jejunum was transplanted into the gastric wall demonstrated that simple exposure to the gastric contents was not the

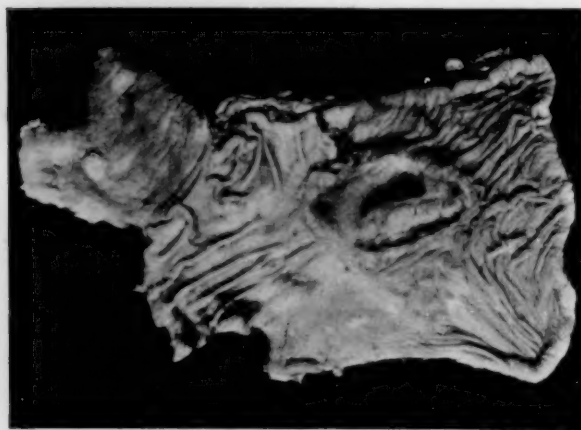


FIG. 2.—Transplant of jejunum to the lesser curvature of the stomach in which an ulcer was found 181 days after operation. The transplant measured 3 by 5 cm. and the ulcer 1.4 by 0.6 cm.

only factor in the production of jejunal ulcer. It is difficult to distinguish the possible effect the acidity of the gastric contents might exert on the jejunal mucosa at the opening of a gastroenteric anastomosis from the mechanical effect of the expulsion of such contents from the gastric cavity. The possibility that the usual site of gastric ulcer is due to an anatomic and functional

difference in the region of the lesser curvature of the stomach from the rest of the organ has been repeatedly emphasized, and all the observations bearing on the suggestion have recently been reviewed by Aschoff.<sup>2</sup> While the hypothesis has not been generally accepted in its entirety, the observations concerning it are sufficient to justify its careful consideration. It is thus evident that, if the situation of peptic ulcer in the stomach is at least partially due to a greater mechanical stress at this site and if there is also a mechanical factor in the location of gastrojejunal ulcer in man, the reason for the failure of ulcer to develop in jejunal transplants in the stomach, may be that at the site selected for the transplant the mechanical factor was of little or no significance.

All the experiments were performed on normal healthy dogs. All operative procedures were carried out under ether anaesthesia and with aseptic technic. Only absorbable sutures were used and intestinal clamps were not employed. The routine operative technic was as follows: The first loop of the jejunum with mesentery sufficiently long to allow it to reach to the lesser curvature of the stomach was exposed and a portion about 5 cm. long resected with its mesenteric circulation carefully preserved. The jejunal loop was then split longitudinally opposite its mesenteric attachment and trimmed to an approximately circular shape. An area of the gastric wall on the lesser curvature near the pylorus, about the same size as the prepared portion of

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the jejunum, was removed and the latter sutured into this opening as a patch. In most experiments the jejunal patch was brought up over the anterior wall of the stomach but in a few experiments it was brought up over the posterior wall. In all cases the patch was placed saddle-wise over the lesser curvature. Great care was exercised in maintaining the circulation to the jejunal patch intact. The continuity of the intestine was reestablished by end-to-end anastomosis. The animals received the usual post-operative care and diet. They were maintained in excellent condition and most of them seemed normal in every respect. At various intervals laparotomy was performed and the condition of the jejunal patch carefully observed. Finally some of the animals were killed under ether. In these instances it was shown that the transplant had an adequate blood supply because marked hemorrhage always occurred when the vein draining the transplant was severed.

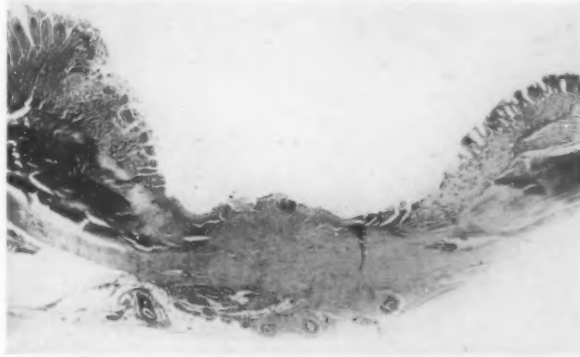


FIG. 3.—Section of ulcer found 117 days after operation. ( $\times 10$ .)

It was fairly easy to perform the operations. The main technical difficulties were: (1) to prevent soiling of the operative field; (2) to maintain an adequate circulation to the transposed jejunum, and (3) to locate the transplant at the desired site. Soiling was prevented by the usual measure of being very careful in packing off the operative field. The circulation to the transplant was assured by selecting a loop of jejunum which had a long mesentery and thus long vessels. The greatest difficulty was experienced not only in locating the transplant definitely on the lesser curvature of the stomach but in preventing it from forming simply a jejunal pouch, similar to a diverticulum. It was found impossible always to place transplant at the desired site.

Transplantation of the jejunum to the region of the lesser curvature of the stomach was successful in twenty-five instances, and a definite ulcer developed in three instances. These were typical peptic ulcers. Careful examination of the transplants in which ulcer developed, either by observing the blood return from the veins draining the transplant or by injecting dye into the artery going to the transplant, demonstrated that the blood supply to the site of ulceration was intact. The transplants in which the ulcers occurred were all located at the desired site on the lesser curvature near the pylorus and formed a definite and contiguous part of the gastric wall with no pouching. The ulcers were situated directly in the line of the lesser curvature. In most of the experiments in which the jejunal mucosa remained normal the transplant not only had not been located definitely over the line of the lesser curvature but it had also become pouched.

The results of the experiments permit two definite statements. When a portion of the jejunum with intact blood supply is transplanted into the lesser curvature of the stomach, the jejunal mucosa usually maintains its normal appearance. In a certain small percentage of instances a typical peptic ulcer forms in the transplanted jejunum. The development of the ulcer is not due to deficient blood supply and apparently does not occur when the jejunum is transplanted to any other region of the stomach.

In spite of the small percentage of instances in which an ulcer developed

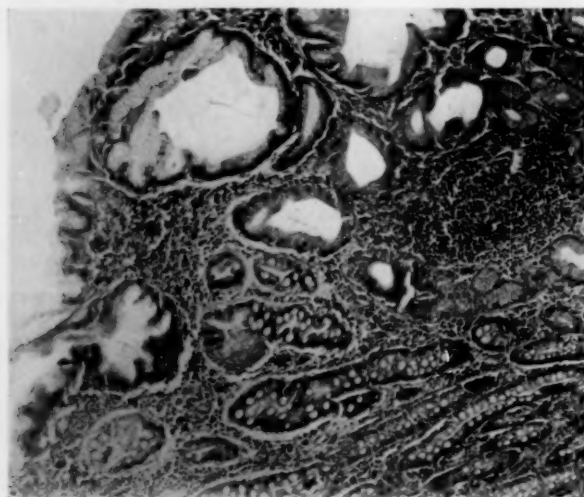


FIG. 4.—Same section as shown in Fig. 3, taken at the site of transition of jejunal and gastric mucosa. ( $\times 75$ .)

in a transplant on the lesser curvature, it would appear to be significant in view of the complete failure of ulcer to develop in transplants in other regions of the stomach. In the study of the various specimens of the transplanted jejunum, the situation of the ulcers and of the transplant in which they occurred at a definite site in the gastric wall appeared suggestive. It is quite possible that ulcer would have occurred in more in-

stances if technically it had been possible to place the transplant always directly over the lesser curvature and to avoid the development of a pouch.

Two interesting observations were made in some of the experiments of this series which may be of some significance in relation to the ulcer problem. In the mucosa of the transplants in which an ulcer developed, there was a marked increase in the goblet cells. In a few instances in the series very few cells other than goblet cells could be found in the mucosa. This observation might be interpreted as the development and possibly failure of the protective elements in the mucosa. In a few animals enormous dilatation of the stomach occurred. In one instance the stomach was so large that it almost filled the distended abdomen. The gastric contents would be retained for three or four days although there was no mechanical obstruction of the gastric outlet. The dilatation occurred in those instances in which the transplant was large and a large pouch had formed. (Figs. 1, 2, 3, and 4.)

#### SUMMARY

Transplants of jejunum with intact blood supply, from the region where gastrojejunal ulcer develops following gastro-enterostomy in man, were made into the lesser curvature of the stomach in dogs at the site where gastric ulcer

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usually occurs in man. A typical peptic ulcer developed in the transplant in a small percentage of instances. This fact appears significant as no ulcers developed when the transplant was made elsewhere in the gastric wall. The results of these experiments add more suggestive data on the hypothesis that mechanical stress is an important factor in determining the site of formation of peptic ulcer.

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## ACUTE DILATATION OF THE STOMACH OCCURRING UNDER GENERAL ANÆSTHESIA

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### AN EXPERIMENTAL STUDY

INTRODUCTION.—It is not remarkable that a symptom-complex presenting features so dramatic as those seen in acute dilatation of the stomach should occupy an important place in surgical literature. The earlier writers, Fagge,<sup>1</sup> Morris,<sup>2</sup> and others confined themselves for the most part to concise descriptions of cases which they had observed. More recently, Conner,<sup>3</sup> Laffer,<sup>4</sup> Borchgrevink,<sup>5</sup> Doolin,<sup>6</sup> Novak,<sup>7</sup> Lee<sup>8</sup> and others have prepared careful analyses and discussions of the cases on record, each writer usually contributing a few cases coming within his own personal experience.

Since the etiology of acute dilatation of the stomach does not rest upon a definite pathological basis, it has been customary to follow Connor's example and group the cases according to the general condition of the patient at the time the dilatation occurred and the circumstances surrounding its onset. The two chief groups are considered to be: First, those cases where the dilatation occurs after surgical procedures, usually abdominal operations; second, those arising as complications during the course of any severe wasting illness. In 1916, Lee<sup>8</sup> added another group, composed of cases in which the dilatation occurred on the operating table while the patient was under the influence of a general anæsthetic. He collected and discussed six such cases, including one of his own. In 1921, Novak<sup>7</sup> referred to eleven of these cases previously described and added two, which had come under his own observation. Abstracts of two of them and of one which recently came under my observation are here presented:

W. G. RICHARDSON<sup>9</sup>.—*Acute Dilatation of the Stomach occurring in the course of an operation for Duodenal Ulcer.* A man, aged forty-seven, entered with history and physical examination typical of perforated duodenal ulcer. The ulcer had perforated at 9 P.M., October 5; he was operated on at 4 A.M., October 6. The abdomen was opened by a vertical incision through the middle of the right rectus muscle, and a perforated duodenal ulcer was found. The hole in the duodenum was closed with catgut purse-string sutures. The operation was simple and easy. There was trouble in administering the anæsthetic satisfactorily. Anæsthesia was induced with chloroform and kept up with ether, given by the open method, and the patient struggled a good deal during induction. He was of bad color during the operation and the respiration was entirely abdominal. During the closure of the peritoneum it was noticed that the upper part of the abdomen was distended. Less than half a minute later the stomach was bulging into the lower part of the wound, and the distention increased so rapidly that the suture had to be unlaced. A stomach tube was passed by mouth. Immediately there was a rush of gas through the tube and the distention disappeared; the respiration became quiet and wholly thoracic; the complexion became pink, the pupils contracted and the whole aspect of the patient changed. Less than



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five minutes elapsed between the beginning of the distention and the recovery. The patient did well after the operation; there were no complications.

EMIL NOVAK<sup>7</sup>.—Woman, aged twenty-nine. Operation: modified Gilliam suspension, and separation of abdominal adhesions. During the course of the operation the stomach suddenly became tremendously dilated, so that it filled the whole upper abdominal cavity and pushed down into the supra-pubic incision. The patient was in the Trendelenburg position; the pulse-rate was only slightly accelerated, and no swallowing movements were observed by the anæsthetist. Within a very short time, certainly less than thirty seconds, the stomach had reached an enormous size. A stomach tube was passed, causing instantaneous collapse of the organ. Within eight or ten minutes the dilatation occurred again, in exactly the same way, and was again relieved by the stomach tube. There was no further recurrence of the distention, either during the operation or during the convalescence, which was uneventful.

M. A. McIVER.—White man, aged twenty-three. Operated upon three hours after an acute perforation of a duodenal ulcer. Ether anaesthesia. The abdomen was opened through an upper right rectus incision. The perforation, located in the first part of the duodenum, was infolded. A posterior gastro-enterostomy was decided upon. At about the time that the posterior wall of the stomach was being drawn through the opening in the mesocolon, the stomach suddenly began to dilate, increasing rapidly in size. Coincident with this dilatation, peristaltic sounds could be heard, suggesting the entrance into the stomach of air from the œsophagus. The anæsthetist stated that the patient was not making any swallowing movements, and this was confirmed by palpation of the larynx. Respiration was abdominal in character. The distention was relieved by introducing a hollow needle into the stomach, permitting the gas to escape. The remainder of the operation and the convalescence were uneventful.

It seems as though the grouping made by Lee and Novak, which is represented by these three cases, were characterized by features distinctive enough to warrant its consideration as a definite entity. In each instance the dilatation has complicated an operation not otherwise remarkable; the patients have all been under a general anæsthetic; the dilatation has been due to a rapid accumulation of gas; the majority of the patients have apparently not shown any grave symptoms\* in spite of the great distention of the stomach; and in most of the cases immediate and permanent reduction of the dilatation has been obtained by passing a stomach tube and allowing the gas to escape. It is natural to conclude that such cases, coming on suddenly and cured by simple means, belong in a different class from the dilatations of the stomach which complicate various types of serious illness: dilatations where the stomach is distended by large quantities of fluid as well as by gas, and which are attended by grave symptoms, by a comparatively long course, a marked tendency to recurrence, and a high mortality.

Although the group of cases in which the dilatation occurs suddenly under a general anaesthesia is a small one, it is probably not so small as one would judge from the number of cases reported in the literature; for practically all surgeons of experience with whom I have talked on the subject can recall one such case or more coming under their observation. It is an interesting problem to attempt to explain the mechanism of this type of dilatation; and it is not adequate to say, as has often been said, that a paralysis of the

\* Lee's<sup>3</sup> case of acute dilatation was complicated by chronic dilatation of the stomach.

stomach occurs, for the dilatation is an active, not a passive, phenomenon; the gas must be introduced under pressure sufficient to balloon out the walls of the stomach. The work of Kelling<sup>10</sup> is of interest in this connection. This investigator showed that in unanæsthetized dogs with a gastrostomy he could produce only moderate degrees of distention of the stomach by pumping air in through the gastrostomy opening, because a regurgitation through the œsophagus emptied the stomach as soon as the intra-gastric pressure rose.

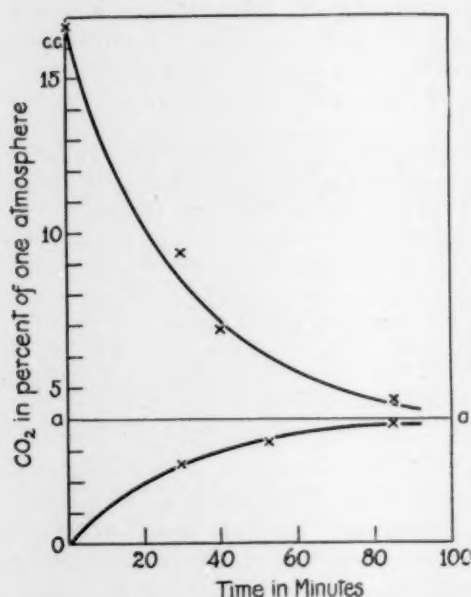


FIG. 1.—When air is injected into the stomach, CO<sub>2</sub> enters until the concentration equals that of the blood. The crosses related to the lower curve show the rate at which this proceeds. When air containing a high percentage of CO<sub>2</sub> is injected into the stomach, CO<sub>2</sub> diffuses out of the stomach into the blood. The crosses along the upper curve show the rate at which this process goes on. The crosses represent actual measurements. The curves are calculated on the assumption that CO<sub>2</sub> is passing by diffusion and not by secretion. The close agreement between the crosses and the curves suggests that CO<sub>2</sub> enters and leaves the stomach by the process of diffusion. The line a—a represents the concentration of CO<sub>2</sub> in the blood.

stomach under normal conditions; and after a series of experiments they concluded that such secretory activity might be responsible, at least in part, for the gas present in acute dilatation of the stomach. In the group of cases now under consideration, however, the rapidity of the dilatation would seem to rule out such a possibility. Furthermore, in studies recently published (McIver, Redfield and Benedict<sup>13</sup>) it was shown that the movement of CO<sub>2</sub> into and out of the stomach proceeds according to the physical laws governing the diffusion of gases and that there is no reason to assume any secretory activity on the part of the gastric mucosa. Fig. 1, taken from the above-mentioned article, illustrates this point: the close agreement between the amounts of CO<sub>2</sub> actually found in the stomach after varying periods of time and the mathematical curves constructed on the assumption that the

If, on the other hand, the dogs were first anesthetized, an enormous degree of distention could be produced without any escape of air. This has a bearing on the amount of distention that may occur, but presents no evidence as to the origin or mode of entrance of the gas causing dilatation in the type of case under discussion. These latter questions constitute our present problem.

ORIGIN OF GAS CAUSING DILATATION.—*Fermentation*.—The possibility that gases arising by fermentation play any rôle in this type of acute dilatation is definitely excluded because of the suddenness of the distention. *Secretion*.—The possibility that the gas might be due to a secretion of CO<sub>2</sub> from the blood stream, abnormally increased by circulatory interference, was suggested to Woodyatt and Graham<sup>11</sup> by Schierbeck's<sup>12</sup> theory that CO<sub>2</sub> was secreted into the

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process is one of diffusion, makes it unlikely that any secretion occurs. *Diffusion from the blood stream.* The amount of gas entering the stomach by diffusion would obviously be too small to play any important rôle in this type of dilatation. *Atmospheric air.* Since gases arising by fermentation, by secretion or by diffusion from the blood stream are not responsible for the type of dilatation under discussion, the question narrows itself to a consideration of the mode of entrance of atmospheric air, the remaining source of gas found in the dilated stomach.

**MODE OF ENTRANCE OF ATMOSPHERIC AIR.**—It has been pointed out in a recent communication (McIver, Benedict and Cline<sup>14</sup>) that during the stage of ether induction and the period of recovery from etherization, considerable amounts of air are often introduced into the stomach by swallowing; and that this swallowed air plays a rôle in the production of post-operative distention. In the cases of acute dilatation now under discussion, however, it is unlikely that air swallowed plays any important part; for most of these dilatations occurred at the end of the operation, when the complex reflex of swallowing would have been abolished by anæsthesia. It is also stated by a number of observers that no swallowing movements of the larynx could be noted at the time the dilatation occurred.

The present investigation has sought to determine whether there exists a

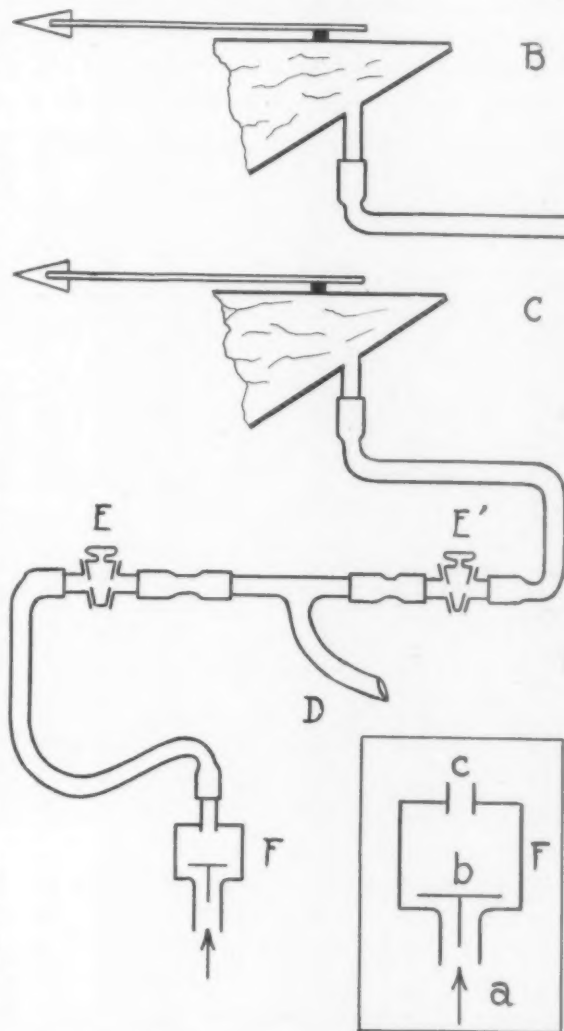


FIG. 2.—Diagram of apparatus. B. Brodie bellows connected with the stomach by means of a rubber tube and hollow needle. C. Brodie bellows connected with glass T-tube D, the stem of which is passed into the upper end of the œsophagus. E and E', Stopcocks. F. Valve permitting the entrance of air, but blocking its exit. Insert: Valve. The inlet is at a. The exit of air drawn into the chamber is prevented by a circular piece of very thin aluminium covered with delicate rubber dam (b). The exit for the air is at c.

mechanism other than swallowing whereby atmospheric air, during anaesthesia, may gain entrance to the stomach under a pressure sufficient to cause dilatation.

Two quite possible modes of action present themselves. The first I believe is reasonable, although I have not so far been able to bring it about in animals. The trachea and the oesophagus open into the pharynx. If some obstruction arose which permitted the entrance of air to the pharynx but interfered with its exit, the air issuing from the glottis would greatly raise the intrapharyngeal pressure and might be forced down the oesophagus, causing a dilatation of the stomach.

A clue to the second possible explanation was obtained in the course of an experiment in which a glass tube had been introduced into the upper

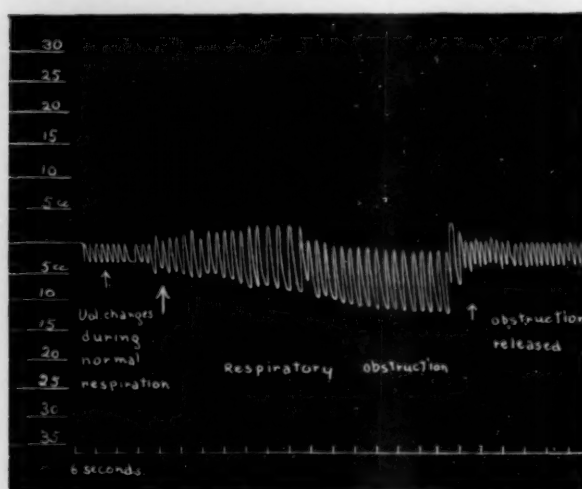


FIG. 3.—This tracing shows the movement of air into and out of the oesophagus during each respiratory cycle, both under normal conditions and during respiratory obstruction. It will be observed that the amount of air drawn in is greatly increased during the phase of labored respiration. The time is shown in six-second intervals.

oesophagus of an anaesthetized animal. During a period of labored respiration, the stomach was observed to dilate, and it was found upon connecting the oesophageal tube with a recording apparatus that a considerable quantity of air passed into and out of the oesophagus at each inspiration and expiration (Fig. 3.) This phenomenon is due to the fact that the oesophagus, in common with other intra-thoracic viscera, is subject to the pressure changes occurring in the chest during each respiratory cycle. Under normal conditions, the oesophagus is collapsed; but if a communication with the outside air is established by means of a rigid tube, the negative pressure created in the thorax during inspiration draws air into the oesophagus just as the blood is drawn into the great veins of the thorax from the veins of the abdomen and neck. In our experiment, during quiet respiration only a few c.c. of air passed into and out of the oesophagus; but during strong respiratory effort caused by obstruction to the trachea, the quantity of air taken in was greatly increased (Fig. 3). It seemed reasonable to suppose, therefore, that if any valve-like obstruction prevented the escape of the air drawn into the oesophagus, dilatation of the stomach would follow. This idea was tested as described below.

THE METHOD.—The experiments were carried out on cats under ether anaesthesia. After anaesthesia had been established, a short midline incision

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was made in the neck, and a tracheal cannula inserted. The stem of a glass T-tube was introduced through the mouth into the upper end of the œsophagus, the tip reaching the level of the upper end of the sternum. One arm of the T-tube was connected with a pair of Brodie recording bellows; to the other arm was attached a sensitive valve which would permit the entrance of air when negative pressure existed in the system, but would block its exit. Stop-cocks were so placed that the T-tube could be connected with either the recording bellows or the valve separately, or with both together (Fig. 2). A hollow needle was introduced into the stomach through a midline abdominal incision and was connected with a second pair of Brodie bellows in order to record any dilatation which might occur.

**THE RESULTS.**—The results of a typical experiment are shown in Fig. 4. The first part of the tracing shows the uninterrupted flow of air into and out of the œsophagus at each respiration. At the point marked by an arrow, the stop-cock was turned, making connection with the valve which permitted the entrance of outside air but blocked its exit. It will be noticed that there was at once an accumulation of air in the œsophagus, causing an abrupt rise in

the tracing; and a dilatation of the stomach followed in the course of about two and a half minutes. Further experiments showed this to be a constant result. The dilatation proceeded rapidly until the stomach was several times its normal size. The gaseous content was approximately 250 c.c. of air, which is about five times the amount of air normally found in the stomach of the fasting cat. The pressure existing in the stomach, as determined by a water manometer, was about 6 cm. of water.

**DISCUSSION.**—It is certain that the force which in these experiments draws atmospheric air into the upper œsophagus is the negative pressure in the thorax. The mechanism, however, causing the passage of the air from the



FIG. 4.—The lower tracing is that of the recording bellows connected with the œsophageal tube, the first part showing the movement of air in the œsophagus during respiration. At the point indicated by the arrow the valve (see Fig. 2) was turned on, permitting the entrance of air, but preventing its escape. The upper tracing records the movements of the bellows connected with the stomach. It will be noted that about two and one-half minutes after turning on the valve a dilatation of the stomach occurred.



upper œsophagus into the stomach is not so clear. The simplest explanation would be that as pressure increases in the upper œsophagus, the air is forced downward into the stomach, which acts as a reservoir the more readily because its muscle tone is lowered by etherization. The downflow of air through the œsophagus is doubtless aided by the fact, pointed out by Meltzer,<sup>15</sup> † that negative pressure is greater in the lower part of the mediastinum than in the upper.

A second process which may play the most important rôle in passing air into the stomach is the peristalsis in the œsophagus. It must be remembered, as pointed out by Cannon,<sup>16</sup> that in cats, as well as in man, whereas the upper two-thirds of the œsophagus are composed of striated muscle, the lower third is formed of smooth muscle. The peristalsis in this smooth muscle is not abolished by etherization, and it seems quite possible that when the pressure

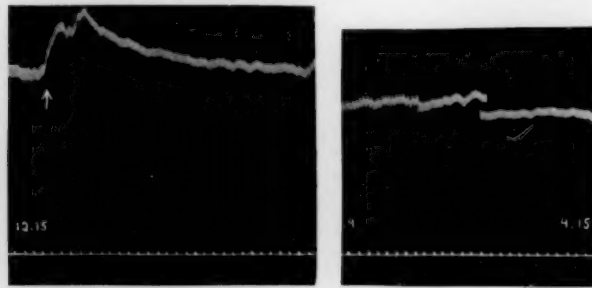


FIG. 5.—Blood pressure taken from the carotid artery. The line at the bottom shows time intervals in five seconds and zero blood pressure. At the point marked by the arrow the stomach was inflated with air. The temporary rise in pressure is a reflex effect; see text. The interval between the two tracings represents a lapse of about four hours, during all of which time the stomach was kept greatly dilated. It will be noted that the blood pressure has been well maintained. The animal was in good condition in other respects also.

in the œsophagus reaches a certain level the accumulated air will be carried by a peristaltic wave down into the stomach. If air is injected into the œsophagus by the means of a syringe, it will then be carried down into the stomach by a wave of peristalsis, as can be observed by opening the thorax under artificial respiration.

In applying these experimental data to the cases of dilatation of the stomach which have been observed clinically to occur under anæsthesia, it should be remembered that the experimental conditions here described differ in two major respects from those prevailing in human cases. In the first place, there is actually no rigid tube, as in our experiments, passing down from the mouth to the upper part of the chest; in the second place, there is normally no valve-like mechanism preventing the exit of air from the pharynx. In regard to the first point: while under normal conditions the œsophagus is collapsed, under conditions of anæsthesia its upper portions may become air-containing. When this is so, the force of negative pressure during inspiration would draw air into the œsophagus from the pharynx. In some of the cases that have been reported there was respiratory difficulty so marked as to be made part of the record; and since an inspiratory effort in the presence of obstruction to the free passage of air into and out of the thorax increases the

† Meltzer estimated this pressure by placing a cannula at different levels in the mediastinum, alongside of the œsophagus. He states that he was unable to obtain constant readings when he made the measurements in the œsophagus, because of its muscular walls and irregular contractions.

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negative pressure, a larger amount of air would be drawn into the upper œsophagus. As regards the second point of difference, the existence of a valve, it seems likely that a dropping back of the soft palate or tongue, in the presence of nasal obstruction, might play such a rôle.‡

*Systemic Effects of Acute Dilatation.*—Clinical observers have for the most part noted few or no systemic effects immediately following gaseous distention occurring under anæsthesia. In a few instances interference with the respiration and increase in heart rate have been noted. In cats, if the stomach be dilated with air, there is at first a rise in systemic blood-pressure which later falls to the normal (Fig. 5). This phenomenon has been described by Dmitrenko<sup>17</sup> as a reflex supposed to occur chiefly through afferent fibres in the sympathetic system. As shown in Fig. 5, the systemic blood-pressure may remain normal, although the stomach has been kept enormously dilated for a number of hours, the pressure being maintained at about 50 mm. of Hg. by the injection of air with the cardia and pylorus ligated to prevent its escape.

In view of the clinical observations and experimental work we may conclude that the first systemic effects of gaseous dilatation per se are slight. The disturbances that have been recorded are attributable to mechanical embarrassment of respiration and heart action due to pressure on the diaphragm. If, however, the acute dilatation, whether of the type occurring under general anæsthesia or of any other type, goes unrecognized or unrelieved, the resulting condition is serious. The greatly distended stomach cannot function; it is unable to empty itself either by way of the intestines or through the œsophagus.§ We have here a condition comparable to pyloric obstruction in rabbits. Since these animals lack the vomiting reflex, the stomach, under the conditions of pyloric obstruction, as pointed out by Gamble and McIver,<sup>18</sup> acts as a reservoir for the large amounts of water and salts that are poured into it by the gastric mucosa, and the animals soon show the effects of dehydration. It seems likely from these studies and from other recent work on high intestinal constriction (White<sup>19</sup>) that most of the symptoms which may be encountered in late stages of acute dilatation of the stomach could be explained on the basis of a severe dehydration with the accompanying loss of chlorides and fixed base.

‡ It was suggested in the earlier part of the paper that in the presence of obstruction to the exit of air from the pharynx the intrapharyngeal pressure would be raised; and since the œsophagus opens into the pharynx along with the trachea, air issuing from the glottis might be forced down into the stomach. It is possible to conceive that an obstruction to the free passage of air into and out of the pharynx might play a double rôle: during the labored inspiration air would be drawn into the upper œsophagus by the increased negative pressure, and during the strong expiratory effort it would be driven into the stomach by the increased pharyngeal pressure.

§ The characteristic vomiting in acute dilatation is merely the regurgitation of small amounts.

SUMMARY

1. The distinguishing features of acute dilatation of the stomach occurring under general anaesthesia are discussed.
2. The gas responsible for the dilatation is shown to be atmospheric air; and the experiments deal with its mode of entrance into the stomach.
3. These experiments show that acute dilatation of the stomach of the anaesthetized cat can be produced by placing in the upper oesophagus a glass cannula connected with the air by means of a valve that permits the entrance of air but blocks its exit. The rôles played by the negative pressure in the thoracic cavity and oesophageal peristalsis are discussed.
4. The immediate systemic effects of dilatation are shown to be slight. The later effects, in cases that are not relieved, may be serious; and it is suggested that many of the symptoms are due to severe dehydration.

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## CAUSES OF DEATH FOLLOWING OPERATIONS FOR PERFORATED GASTRIC AND DUODENAL ULCERS

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It is the general impression that the important factors in determining the death of patients suffering with perforated gastric and duodenal ulcers, are, first, the length of time which has elapsed between the rupture of the ulcer and operative interference; secondly, the proximity of the time of perforation to the ingestion of food with the consequent variable gross soiling of the peritoneal cavity, and thirdly the rapidity with which the operation is performed. As a rule nothing or very little is said of several other factors causing death and yet they are almost as important as the most weighty factor, *i.e.*, the time elapsed between rupture and operation.

The following considerations are based upon a study of the records of eighty-eight patients from the surgical service of the Mt. Sinai Hospital since January 1, 1915. Many of these patients were personally observed and operated upon by the writer. There has been no attempt to differentiate the duodenal from the gastric ulcers, for in our experience it has been almost impossible, and, indeed, fruitless to tell them apart clinically. Even at laparotomy the landmarks are so obliterated by the products of inflammation when the ulcer is in the neighborhood of the pyloric ring that the term *gastroduodenal* must be used. The constriction at the duodenal-pyloric junction and the pyloric vein are not usually visible.

Of these eighty-eight patients, twenty-seven died, *i.e.*, 31 per cent. The death rates in the practice of surgeons in different hospitals and in different localities vary considerably, for there is not nearly the uniformity in percentage of mortality as in the case of other more common surgical diseases such as acute appendicitis. From year to year the mortality changes, so that in one the rate is zero, and in another as high as 54 per cent. A comparative study of death rates in perforated gastroduodenal ulcers is of little importance. Perforated gastroduodenal ulcer is such a catastrophe in which the peritoneal cavity is suddenly and frequently, overwhelmingly invaded by a hostile horde of chemical and bacteriological forces, that the outcome depends more upon the strength of these forces and the patient's ability to cope with them than upon the act of the surgeon.

*The Duration of Time Between Rupture and Operation.*—Our records agree with the universal experience that the mortality increases almost in direct ratio to the number of hours elapsing between rupture and operation.

Because this factor is so sure and so well known it requires little comment.

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It is very striking, indeed, that not a single patient died when operated upon within six hours after perforation. This factor of the lapse of time between perforation and operation needs qualification. There is a small group of

TABLE I.<sup>1</sup>

Hours after perforation	No. of patients	No. of deaths	Per cent. of deaths
to 6	27	0	0
7 to 12	26	7	27
13 to 24	12	3	25
25 and above	19	14	73

<sup>1</sup> When the total number of cases in this and the other tables is less than the total 88, the relevant data have not been available in the missing cases.

patients who come to operation more than twelve hours after perforation, but in whom there is little or no spilling of stomach contents and only a localized inflammatory reaction. This is illustrated by the following case history:

Morris D., age thirty-seven years (operation by Dr. J. B. Stenbuck, 1923), stated that he was suddenly seized with severe epigastric pain thirteen hours prior to operation and that the pain persisted, though after several hours somewhat abated, to the time of admission to the hospital. On physical examination, the signs were those of marked peritoneal irritation including the usual board-like rigidity. When the abdominal cavity was opened there was no escape of either air or fluid, and, indeed, no inflammatory reaction was seen. A tab of omental fat was adherent to the anterior surface of the antrum of the stomach in the region of the pyloric ring. Only upon detaching this tab of fat was it possible to see the ulcer which then began to emit gas and gastric contents.

In this instance there had been apparently an acute perforation of the ulcer thirteen hours prior to operation, but a tab of fat had walled it off by acting as a stopper to the gastric contents. We must differentiate this type of case from that in which there might have been for thirteen hours a more or less constant outpouring of gastric or duodenal contents into the peritoneal cavity and in which the outcome is obviously unfavorable. It is the type of case illustrated by Morris D., that we may expect to find not infrequently that the patient has recovered from operation even though operated upon long hours after perforation. This type of case is in marked contrast to the more common type in which there occurs a virtually continuous explosion. The exact time of walling off is practically impossible of estimation, though the cessation of the severe abdominal pain is suggestive of it. In our records not infrequently there is a history of short periods of acute epigastric pain with remissions for one or two weeks prior to the very acute attack which sends the patient to the hospital. Possibly on the previous occasions there have been heroic attempts on the part of the omentum and the serosa to seal the orifice of the perforating ulcer. There may have been a succession of mild perforations, temporarily walled off, ending, however, in rupture into the free peritoneal cavity. There is a case operated upon as much as three days after time of apparent rupture in which there was recovery.



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Thomas T., age forty years (operation by Dr. R. Lewisohn, 1917). His history, typical of ulcer, extended over a period of five years prior to admission, during which time there were attacks similar to the present of severe epigastric pain occurring at intervals of about six months. The last attack began about three days before admission and was more or less continuous. At operation a small amount of serous fluid was found in the peritoneal cavity, but there was no peritonitis. There was a perforation, pinhead in diameter.

Another case operated upon twenty-eight hours after rupture affords unusual interest:

Isadore L., age forty-two years (operation by Dr. J. C. A. Gerster, 1924), had an attack of severe epigastric pain two years previously, similar to the present one, and it lasted in varying degree about two weeks. There were several milder attacks in the interim. The present attack began twenty-eight hours before admission and continued with varying intensity until time of operation. Just before operation a röntgenogram showed free air in the peritoneal cavity between the diaphragm and the liver. At operation free gas escaped from the peritoneal cavity and there was a small amount of peritoneal fluid. No perforation was found, although obviously it had occurred. Thick yellow fibrinous exudate covered a small area on the surface of the antrum of the stomach and beneath it was the induration of an ulcer. The presence of the ulcer was corroborated when, in the performance of gastro-enterostomy, a finger was introduced into the lumen of the stomach.

In addition to qualifying the factor of time elapsing between perforation and operation, these cases suggest very strongly the probability that perforated ulcers may heal spontaneously. At least they demonstrate in some cases the importance of physical resistance as compared with surgical assistance in rescuing the patient from death.

*The Operative Procedure.*—The majority of surgeons are in favor of the simplest form of operation which is closure of the ulcer in two or three layers. They reserve gastro-enterostomy for those cases in which the marked constriction of the pylorus whether due to either operative suture, or scar tissue, or œdema requires it. This adherence to a simple procedure is in harmony with the customary teaching that for the good of the patient it is urgently advisable to "get in and get out" of the abdominal cavity with the utmost rapidity. Of twenty-eight patients of various stages upon whom a gastro-enterostomy was performed in addition to closure of the ulcer, only four died, a mortality of 14 per cent. Many of these were advanced cases with peritonitis. The mortality is low in comparison with 31 per cent. in all our cases and suggests the possible beneficial effect that may have been brought about by improved drainage by way of the gastroenteric stoma.

In the absence of constriction in the pylorus or duodenum, closure of the orifice when properly performed will suffice. The proper closure does not entail any elaborate suture. It is possible that one purse string inserted into firm tissue will be enough to prevent further leakage of gastric or duodenal contents and allow the ulcer to heal. The following case is of interest in this connection:

Raymond M., age twenty-four years (operation by Dr. J. B. Stenbuck, 1925). A perforation occurred on the anterior surface of the stomach near the pylorus. There was

a considerable collection of bile-stained fluid and of gas in the region of the ulcer and in addition a generalized peritonitis. The orifice was closed by means of a silk purse-string suture and the stomach was imbricated over it by means of three interrupted silk sutures. Seven days after operation the patient died of a generalized purulent peritonitis. A post-mortem examination was performed by Dr. B. Eliasoph. He removed the stomach, tied off the duodenal end, introduced about three quarts of water through the œsophageal orifice, and then tied off this end. The stomach was seized in both hands and gradually increasing degrees of pressure were exerted, but none that could be employed disturbed the suture line. The three imbricating sutures were then removed. Again gradually increasing pressure was applied and considerable force was required to dislodge the remaining single purse-string suture. Although manometric determinations of the intragastric pressure were not made, this constitutes a rough test of the adequacy of a simple suture.

In those cases in which a purse string or layer suture can be applied sufficiently to close the perforation, it is not necessary to use a tab of omental fat which then becomes a mere refinement. In those cases, however, in which perforation is of such large size or the stomach wall next to the orifice is so friable that proper closure cannot be made, the omental fat tab placed into or over the orifice may prove invaluable.

*Drainage of the Peritoneal Cavity.*—The relation of drainage of the peritoneal cavity to mortality is frequently discussed. On the one hand, it is believed that it is impossible to drain the peritoneal cavity by means of either a rubber tube or with gauze or, indeed, with any mechanical contrivance at our disposal. It is believed that with the discontinuance of the so-called drainage of the peritoneal cavity the mortality rate has been appreciably diminished. Since, however, the mortality rate varies considerably from year to year, no change in the rate should be attributed necessarily to the procedure which it follows. On the other hand, the drainage tube is considered a sort of safety vent for any possible local accumulation of pus.

In the majority of our cases drainage devices were inserted, and occasionally counter-drainage by way of a stab wound to the pelvis, but it has been our almost uniform experience to find an extremely negligible quantity of drainage even in those cases in which stomach contents and exudate were lying in the peritoneal cavity. It is my impression that after the source of peritoneal soiling is eliminated and the proper toilet of the abdominal cavity is performed, it is for the patient to remove whatever soiling remains since little help may be expected from the drainage devices.

*The Size of the Perforation.*—In general small perforations were attended with recovery while large perforations allowed of a higher mortality. The perforations were small, either because approached before they had an opportunity to develop, or because they had been sealed over or patched up by omental fat tabs. The greater opportunity for peritoneal soiling in the case of a large orifice is obvious. It is possible that a perforation is large either because it became so with a sudden explosive force or because the patient's local or general resistance was insufficient to prevent a small ulcer from developing into a large one.

The quantitative soiling is not as important a factor as it would seem at first consideration, but rather, those same factors (poor resistance) which

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allows the production of a large ulcer may allow also the chemical and bacterial irritants and toxins from the stomach to spread devastation throughout the peritoneal cavity.

*The Constitution of the Patient.—Age.*—The mortality rate increases in equal steps with the ages of the patients. Our youngest patient was twenty-three years old and the oldest seventy-five years. The deaths according to decades are arranged in Table II.

TABLE II.

Age	No. of cases	No. of deaths	Death rate
			Per cent.
20-29 yrs.	16	1	6
30-39	30	6	20
40-49	15	4	26
50-59	15	10	66
60-69	7	4	57
70-79	2	2	100

*Sex.*—Only two of our eighty-eight patients were women. One died. No deductions of course may be drawn from this small number.

*Organic Disease.*—Chronic cardiovascular, kidney, and pulmonary disease were predisposing factors in the post-operative mortality. This is true in all surgical conditions, but particularly in those in which the onset is sudden and severe. The lessened reserve force which comes from chronic illness may be able to cope with a mild or slowly progressive surgical condition, but it is as a rule helpless before the overwhelming force of such an explosive disease as perforated gastroduodenal ulcer. This is best illustrated by the fact that the biggest proportion of deaths occur in the older patients, for old age is, after a fashion, chronic organic disease.

*Acute alcoholism* plays a varied rôle in death. Two quite intoxicated patients whom I observed died, one five hours, the other six hours after operation. The operations were performed, respectively, thirty-two hours and twenty-five hours after the time of rupture as reported by friends of the patients. In alcoholic debauches, in addition to fluids, large quantities of food frequently are ingested, and the sudden overdistention of the stomach with carelessly chosen and often irritating food may well have a deleterious effect. The intoxicated patients are really in varying stages of narcosis so that they either may not feel the onset of perforation or may not, if they feel, realize the import of the pain. They may not seek surgical aid and, indeed, may even resist the importunities of their more conscious friends who have noticed the acute physical manifestations of the onset of perforation. In addition, the chronic alcoholic, with weakened resistance succumbs to disease more easily.

*The Three Periods or Modes of Death After Operation.*—In Fig. 1, I have grouped the deaths according to the time they occurred after operation. (Fig. 1.)

It will be observed that one group is composed of patients who die within three days after operation, another is made up of those who die about a week (six to ten days) after operation, and a third of those who die one to two months after operation. These are not, in my opinion, chance

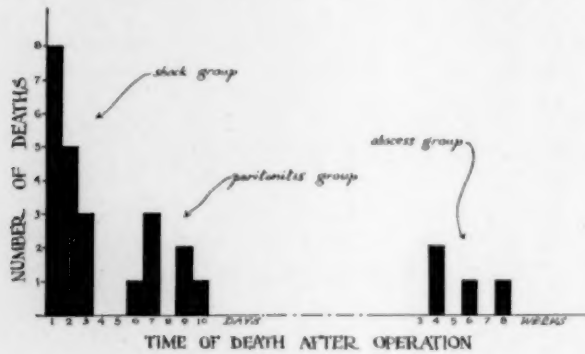


FIG. 1.

groupings. I believe they represent three different modes in death which may be differentiated clinically and pathologically. GROUP I.—In those patients who die within three days (mostly within one day) after operation, the preponderant factor in *shock* which is noticeable before operation and continues unabated until death after operation. While autopsy may reveal a diffuse soiling of the peritoneum and early peritonitis, it is *as a rule* too early and too slight to cause death. This overwhelming chemical and bacterial shock is exaggerated according to the patient's inability to cope with it. Some patients may overcome it and survive, some others may overcome it temporarily only to succumb later, according to their powers of resistance. We should expect to find in Group I the patients of advanced age and those with chronic organic disease. It is interesting to note that of the sixteen patients who died within three days post-operative, twelve were fifty years old, or older, and only four were below fifty years of age. Because of their lessened reserve they die very easily in pulmonary, cardiovascular, or renal collapse rather than from infection *per se*. In this group the patients make their exitus in a violent sort of death. There is no free interval in which the patient feels improved by the operative procedure, but he is desperately sick every minute from the onset to the end of his very short illness.

GROUP II.—In the second group the patients die of a generalized purulent *peritonitis*. They pass through the period of shock very quickly. They feel better after operation and they seem to be combating the disease successfully for a few days so that the surgeon is tempted to make a favorable prognosis. Then very surely the patient's temperature mounts, the pulse becomes more rapid and labored, and the expression anxious. These signs of peritonitis are followed by death. In this group are the younger patients who are sufficiently vigorous to withstand the early shock, but are unable to ward off the infection which spreads. Of the seven cases of death in this peritonitis

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group, the age distribution was as follows: only two patients were above fifty years of age, and five patients were less than fifty years of age.

GROUP III.—The third may be termed the *abscess* group. The abscess may be subphrenic or within the liver. In our cases there were two deaths of each variety. In the case of liver abscess the patients pass successfully through the periods of shock and of peritonitis and at the end of the second or third week they may appear quite normal and ready for discharge when they begin to experience pain in the abdomen just beneath the operative wound or in the region of the liver. The temperature and pulse rise and there may be a chill or chilly feeling with a cold clammy perspiration. Abnormal pulmonary signs usually at the right base may be elicited and are due, as a rule, to the elevation of the diaphragm and the production of some pleural fluid which later may become purulent. The abscess becomes larger and larger. There may be several abscesses. The condition does not respond to surgical treatment mainly because of the difficulty in draining abscesses which are multiple, and with gradually increasing toxæmia and cachexia and actual destruction of a considerable amount of liver substance, the patient dies in one to two months post-operative.

Subphrenic abscess as a complication of perforated ulcer causing death is mentioned not uncommonly. Most probably its origin may be explained by a purulent residuum over the dome of the liver, or by a superficial liver abscess which has ruptured beneath the diaphragm.

Liver abscess, on the other hand, as a factor in death after operation for perforated ulcer is an unusual condition and has received scant mention or none at all in the clinical and pathological considerations of the subject. We have been unable to find any report of such cases in the literature though it is possible that some of the cases of subphrenic abscess reported were originally liver abscesses which ruptured. The possible modes of infection in liver abscess are: 1. By way of the portal vein from the ulcer, from the peritoneal infection, or from the infected abdominal wound. 2. By direct extension from the ulcer which may lie contiguous to the liver, and 3. From a suppurative cholangitis.

Clinically the condition was not diagnosed at its onset but attention was called to the subphrenic abscess which overlay it in each of our two cases. In one, the presence of the subphrenic abscess masked the liver abscesses which lay beneath it and it was only by aspiration of the liver at the time of operation for drainage of the subphrenic abscess that the presence of the abscesses in the organ could be elicited. In the other case the liver abscesses were discovered at post-mortem examination.

CASE I.—G. F., age fifty-eight years (operation by Dr. E. Klein, 1923), was operated upon May 5, and died July 4. For five or six years prior to admission he had had stomach trouble which consisted of epigastric pain with sour eructations occurring about two hours after meals, which were relieved by bicarbonate of soda. Nine hours before admission he had an attack of severe epigastric pain. Before operation physical examination showed generalized abdominal rigidity and tenderness more marked in the epigastrium and obliteration of the area of liver dullness. At operation the upper abdominal cavity con-



tained a moderate amount of sero-purulent fluid. On the anterior surface of the pylorus was a perforation 3 mm. in size, surrounded by an acute inflammatory process involving the wall of the stomach. The orifice of perforation was sutured and because of the constriction of the pylorus a posterior suture gastro-enterostomy was performed. A soft rubber tube was placed as a drain in the region of the foramen of Winslow.

May 7, signs of pneumonia developed at the left base.

May 22, there were signs, corroborated by röntgenograms, suggestive of a subphrenic abscess but aspiration revealed no pus. The condition of the patient became progressively poorer. A mild fever (90° F. to 100° F.) persisted until the middle of June when the temperature rose daily to nearly 103° F. and continued to do so until death on July 4.

July 2, a preliminary walling off of the pleural cavity was performed and on July 3, the subphrenic space was entered and a small abscess in it was drained.

July 4. Post-mortem examination showed a healed gastric ulcer. There was no pus present in the abdominal cavity, but many adhesions had formed between the inferior surface of the diaphragm and the dome of the liver. In the uppermost portion of the liver substance, immediately beneath the surface was an abscess 6 cm. in diameter. There were two small abscesses having a diameter of 1 to 2 cm. close by. The intervening liver tissue showed irregular areas of dark red infarction. The gall-bladder, the bile ducts, the portal vein and the hepatic vessels were grossly negative.

CASE II.—B. G., age thirty-seven years (operation by Dr. J. B. Stenbuck, 1924), was operated upon October 8, and died November 26. His previous gastric history of only two weeks' duration consisted of mild, constant, non-radiating epigastric pain not related to meals. Eight hours before operation there was a sudden attack of very severe epigastric pain. Physical examination showed signs typical of perforated gastroduodenal ulcer. Operation revealed a perforation about 0.5 cm. in diameter on the anterior surface of the antrum near the lesser curvature. The perforation was closed by means of three layers of sutures. In the upper portion of the abdominal cavity there was a large collection of bile-stained, thick fluid which extended above the dome of the liver. The fluid was mopped with sponges and aspirated. A soft rubber tube was placed to the region of the pylorus.

Immediately after operation the patient developed signs of diffuse bronchitis which disappeared in a few days.

October 18, thick pus was evacuated from the lower part of the abdominal wound. The patient's temperature became normal and he appeared to be quite well and ready for discharge from the hospital as soon as his wound should heal.

October 26, the patient experienced pain in the right hypochondrium and right flank, and there was tenderness in this region. The pain continued, the temperature rose sharply to 103° F., and there were flatness and diminished breath sounds in the lower portion of the right chest. These signs and symptoms suggested a subphrenic abscess. A röntgenogram showed a slight elevation of the right diaphragm with increase in the lung markings at the right base which were probably due to compression.

October 29, aspiration was performed in the tenth interspace in the midaxillary line, which was the point of maximum tenderness, and a few drops of very thick pus were obtained.

November 2, the subphrenic space was entered, pus evacuated from it, and drainage instituted. Nevertheless, the temperature continued elevated, and therefore the wound was revised and another pocket of pus discovered apparently in the liver substance. The fever remained high.

November 9 and November 13, the wound was reentered and the liver was penetrated by the aspirating needle and pus was obtained beyond what appeared to be grossly healthy liver tissue. The barriers of liver substance which separated what were evidently multiple liver abscesses were broken down to form one large cavity. However, the abscesses which went to form this cavity had destroyed almost all of the right lobe of the liver.

The patient became rapidly worse and died November 26.

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These cases of death from liver abscess present similar pictures. Most probably infection brought to the liver by way of the portal vein, proliferated in the small branches. Although the quantity of bacteria might be quite small they would, in the weeks of illness, finally produce large abscesses. Although the bacteria might be diffusely disseminated throughout the liver, they might not produce diffusely disseminated abscesses but only multiple purulent foci. It is possible that the smaller abscesses might coalesce to form larger ones.

Clinically, in the onset of development of these abscesses, it is remarkable that there may be no abnormal signs. Yet this is in conformity with the occasional experience in liver abscess not related to operation, in which the physical signs and symptoms are almost negligible. Indeed, it is most probable that the condition does not present itself to us until a subphrenic abscess is formed, due possibly to the subdiaphragmatic rupture of a superficial liver abscess.

In each of our cases the abscesses of the liver were multiple, in each they seemed to have become progressively worse and involved a considerable quantity of liver substance, and each did not respond to operative treatment. In the nature of the multiplicity and dissemination of the abscesses and the impossibility of draining all of them, operation will offer no hope of succor.

### SUMMARY

The time which has elapsed between the time of rupture of a perforated gastroduodenal ulcer and the time of repair is the most important factor in determining the fate of the patient. There are, however, other factors of considerable importance: age, the type of operative procedure, the repair on the part of the omentum, the size of the perforation, the amount of gastric or duodenal contents spilled, organic disease, and alcoholism.

After operation death occurs in three distinct groups. In the first group, death occurs within three days, usually within twenty-four hours, after operation, and is due almost entirely to the element of *shock*. In the second group, the patients appear to be improving, only to succumb to diffuse *peritonitis* in approximately a week after operation. In the third group, the patients after overcoming the elements of both shock and peritonitis die in several weeks or months after operation, due to subphrenic or liver *abscess*.

Death from abscess of the liver occurred twice in our series of eighty-eight cases, and since it is an extremely rare condition both cases are here recorded.

## TUMORS OF THE CÆCUM \*

DISCUSSION AND REPORT OF FORTY-EIGHT CASES

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AMONG the more common varieties of tumors of the cæcum appearing in the literature of the day are cystic, including dermoid, epidermoid and entero-cystoma with tumors of the following varieties—leiomyoma, actinomycosis, lympho-sarcoma, carcinoma—standing out most prominently with tuberculosis, chronic inflammatory hypertrophy and the occasional lympho-sarcoma. We mention the latter in the order of frequency in which we have seen them.

Carcinoma was found in thirty-seven instances, tuberculosis in seven, chronic inflammatory in two and lympho-sarcoma in one. One undetermined possibly following appendix phlegmon.

For the sake of completeness, a brief review of anatomy with emphasis on the cæcal lymphatics is necessary.

*Anatomy.*—In a normal adult the cæcum is about two and one-half inches in length. A fold running from the top of the ileum partly around the large gut, marks the boundary between the cæcum and the colon. The cæcum differs from the rest of the large gut in that it is more richly supplied by the lymphatics. It is lined with a single layer of columnar cells.—Villi and valvulæ conniventes are absent.

The vessels of the mesentery and nerves enter the cæcum and colon from the inner or left side. This may be explained embryologically since the cæcum and the colon originally occupied the left lower abdominal segment, later they rotate to the right, remaining permanently in the right iliac fossa.

The blood supply to the cæcum is the ileo-colic branch of the superior mesenteric. The ascending colon is supplied by the right colic, and the transverse colon by the medial colic.

The lymphatic drainage follows the course of the ileo-colic blood-vessels. Frequently they are continuous with glands around the superior mesenteric artery. The terminations are associated with the ileo-colic arterioles.

Lymph channels surround the glands of Lieberkuhn where carcinoma of the cæcum originates. From here they are directly continued to the network of the lymphatics in the submucosa. These pass through the muscle layers and form plexuses of lymphatics between the mesenteric sheaths.

\* Read before a conjoint meeting of the New York and Philadelphia Surgical Societies, February 9, 1927.

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The lymph systems may drain into five different groups of glands about the cæcum or directly into the glands around the ileo-colic artery above.

The groups as given by Craig and MacCarty are: 1. Anterior colic. 2. Posterior colic. 3. Appendicular. 4. Ileal. 5. Right colic.

*Lympho-sarcoma.*—Lympho-sarcoma is an extremely rare disease of the cæcum. During a period of fifteen years in Prague, of 13,036 sections, thirteen cases were found. It does, however, occur with more frequency in the small intestines and rectum.

The symptoms are similar to other types of cæcal tumor, occurring in early adult life. The tumor is extremely rapid growing and non-tender.

It begins in the submucosa made up of small or large round cells. Within a very short time the entire gut wall is infiltrated. The central portion breaks down and ulcerates. Extension takes place peripherally. With sarcomatous invasion the gut has a tendency to be dilated rather than to be constricted in contra-distinction to carcinoma. Polypoid excrescences are not usual.

The course is rapidly fatal. Metastases occur early in the contiguous lymphatics and likewise in the distant organs.

Early recognition and excision followed by Röntgen and radium therapy offers the best prognosis. A few cures have been reported.

In our series we had one case reported to be lympho-sarcoma.

*Tuberculosis.*—There is now rather general agreement that tuberculosis does occur primarily as well as secondarily in the cæcal region. The pathological differences are quite marked. This in a given case, together with absence of tuberculous foci in the other regions, furnishes strong support for those contending primary invasion.

Tuberculosis of the cæcum is very common in patients having pulmonary involvement. At necropsy it has been demonstrated that the gastro-intestinal tract is involved in 70 to 90 per cent. of these cases. (Hartman quoted by Menzies.) Of this number the ileo-cæcal region is involved in about 85 per cent. of the instances. Only a relatively small number of this group receive surgical interference, and then only when symptoms of obstruction, fistulæ and severe subjective signs are present.

The best explanation offered for the predelection of the ileo-cæcal region is based on anatomy. As cited previously the cæcal region of the large gut, excepting the rectum, is the most abundantly supplied with lymphoid tissue. In children the infection is attributed to milk inoculation by the bovine type of bacillus. In adults it is ingested with the food, or transmitted through the blood stream, and the organism is the human type.

The age incidence is early adult life between the second and third decades, although of our series of seven cases reported, the average age was under twenty years. As regards sex there was equal distribution.

There is nothing in the symptomatology characteristic of tuberculosis unless it be the insidious onset, chronicity and interval periods of freedom

from symptoms. The duration in our series extended from two months to five years.

Pain is an early evidence, full at first, later cramp-like and irregular. Associated with this is tenderness and rigidity in the right lower quadrant. Obstinate constipation with diarrhoea and blood-streaked mucous shreds is a prominent symptom. Epigastric discomfort, nausea, vomiting and belching occur early. The absence of temperature means little, its presence, particularly in the afternoon, may augment the differential diagnosis.

Serum tests in adults are of very little aid. Pulmonary, osseous and glandular involvement must always be sought for. We were able to demonstrate phthisis in one instance; and no extra-cæcal focus in the others.

Brown, Levy and Haft all emphasize the difficulty of clinical recognition, and stress the value of the Röntgen examination, also see the article by J. W. Larrimore and A. O. Fisher, *American Surgery*, p. 496, April, 1926. The former reports that in twenty-eight cases diagnosed and operated, twenty-seven were diagnosed correctly. His work upon this subject has been painstaking and most illuminative. The Röntgen picture in cæcal tuberculosis reveals hypermotility, spasticity, and filling defect. Obstruction when present is likewise disclosed.

Pathologically, there are two distinct types of cæcal tuberculosis. (1) Ulcerative, (2) Hyperplastic.

(1) Ulcerative: Menzies describes this type as the enteroperitoneal group. The tubercles are first found in the mucous membrane. As they grow they coalesce, undergo central degeneration and produce superficial flat ulcers with undermined edges. Read states that the ulcers circle the gut because the lymphatics and vessels run circularly. As a result, on healing the cicatrix forms an obstructing band. He maintains that 25 per cent. of the ulcerous type produce stricture or stenosis. Similar tubercles in the serosa produce a dense adhesive peritonitis. This group is considered a secondary manifestation of a primary focus elsewhere. It is surgical only when obstruction makes intervention imperative.

(2) Hyperplastic: This group is considered to be primary in origin. Surgical excision frequently perfects a cure. The tubercles appear in the submucosa, growing there, causing thickening of the wall and narrowing of the lumen. Menzies claims that by the fibrolipomatous changes in the pericæcal fat there is a tendency to self-limitation of the tumor.

Our cases represent both these types of tumor and secondary infection had played an important part in the syndromes. All cases showed degrees of obstruction. Three were of the hyperplastic type, one of which was complicated by a fecal fistula. Two showed papillary projections of the mucous membrane. One was of the ulcerous, constricting type with the primary focus in the right middle lobe of the lung. It is interesting to note that all had at various times been diagnosed as appendicitis. Two had had appendectomies, one of which resulted in the fecal fistula mentioned above



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and this latter one was a primary perforation of a tuberculous ulcer of the cæcum.

A Friedrick resection with a side-to-side anastomosis of ileum to transverse colon was done in one stage in three instances. Because of the extreme dilatation of the ileum in the ulcerative case, only the resection of the tumor and an ileostomy (Paul's tube) was attempted at the first stage. Eleven days later the anastomosis was completed similar to the others.

The results were uniformly good. There was one death out of seven patients, a child two and a half to three years old, with tuberculosis of the cæcum, who had an appendectomy done, the other patients leaving the hospital apparently cured. Responses to follow-up letters revealed freedom from symptoms and marked general improvement.

*Carcinoma.*—In this series of cases the youngest was twenty-one and the oldest seventy-eight. Attention has been called to the fact that carcinoma of the intestinal tract occurs with far greater frequency in the fore-gut and the hind-gut. The mid-gut, extending from the second portion of the duodenum to the ileocaecal valve is relatively free from invasions. It seems, therefore, that that portion of the gut functioning to prepare and digest food and also that portion which has to do with the storage and evacuation of unassimilated food is peculiarly susceptible to carcinomatous invasion.

Brill (quoted by Ewing), in reporting 3563 cases of malignancy of the intestines, found only eighty-nine, or 2.5 per cent., of instances in which the small intestines were involved. Of this number, the greatest percentage occurred in the second portion of the duodenum about the biliary papilla.

In an article by J. F. Erdmann and R. F. Carter, *New York Medical Journal*, June 7, 1922, the senior author reports the following frequency of malignancies of the colon in a series of one hundred and twenty-nine cases: Fifty in the recto-sigmoid, rectum and anus; thirty-seven in the sigmoid; eighteen of the cæcum; fifteen of the ascending colon, hepatic flexure and right half of the transverse colon; nine cases in the left half of the transverse colon and splenic and descending colon.

Tissue predisposition is evident in those instances in which malignant changes develop from polyps of the colon. Trauma due to physiological and anatomical relationship plays a definite rôle. No doubt those portions of the gut which are fixed and offer more resistance to fecal movements are subjected to a more constant irritation. This resistance probably being greatest at the ileo-cæcal junction and at the rectal valves.

*Pathology.*—Tumors of the cæcum are characteristic of tumors elsewhere in the colon. They are slow growing, only moderately malignant, extending late and metastasizing less frequently than tumors of a similar nature in other organs.

Carcinoma begins in a circumscribed area of mucosa, with enlargement of the glands and permeation of the basement membrane. This area gradually extends by progressive transformation of normal into neoplastic alveoli.

Microscopically this process can be demonstrated and one may frequently see papillary outgrowths of mucosa surrounding an ulcerated tumor.

Ewing gives the following gross and microscopical classification:

1. Adenoma Destruens.—A bulky ulcerating tumor causing obstruction, fistulae and anastomosis.
2. Stenosing Fibro-carcinoma.—First produces a superficial ulcer with marked fibrotic induration. It has a tendency to be annular, causing constriction of the lumen and infiltrating tissue and nodes early.
3. Colloid Gelatinous Adenocarcinoma.—Bulky, spreads rapidly and ulcerates early. This type produces miliary nodules in the peritoneum. Lymphatics are involved later.
4. Multiple carcinoma from polyposis.
5. Papillary carcinoma from single polyps.
6. Melanoma.

Colloid carcinoma or gelatinous of Ewing, differs from adenocarcinoma only in that it is a degenerating form. Parhan describes it as lack of functional control of the secreting epithelial cells. This functional differentiation of cells corresponds to morphological differences seen in carcinoma cells of the acinar or columnar type. He observed colloid carcinoma in 22 per cent. of all malignancies of the cæcum. In our series, with a recent pathological "check-up" of specimens, we found only 18 per cent. conforming to the type.

Metastasis is rather late and recurrence is usually found at the site of origin. Death may be delayed in colloid carcinoma but the eventual mortality is greater than in other types. Parhan points out that the signet ring cells tend to be more malignant than the glandular type with columnar growth.

The most frequently involved group of lymphatic glands are the posterior colic. In the Craig and MacCarty series of one hundred cases studied with particular attention paid to glandular distribution, 71 per cent. of all glands found were in this region, and 64 per cent. of the glands showing metastatic involvement belonged to this group.

This may be explained by the frequency of involvement of the ileo-cæcal valve in malignancy of the cæcum (50 per cent. Ewald to 64 per cent. Craig) posterior wall alone in 35 per cent. When the valve was involved in the growth and regional metastases were found, the posterior colic chain showed tumor cells in 78 per cent. The surgical significance of the group is at once apparent.

Craig and MacCarty concluded, "The size of intestinal lesions and the size and number of regional lymph-glands proved to be no criterion for the presence or absence of metastasis." They found regional glandular involvement in 32 per cent. of their one hundred cases.

Many glands are hyperplastic, œdematous and simulate malignancy, only to be found on biopsy to be inflammatory reactions. In our series in 25 per cent. we were able to demonstrate carcinomatous infiltration. Furthermore, cases which clinically are of the low malignant variety tend to have larger and more numerous hypertrophic glandular changes. When the glands are

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involved in the carcinomatous process, clinically the picture is more severe and the prognosis as to cure much more unfavorable.

Secondary infection invades tumors early and plays a leading part in the rapidity of growth and formation of fistulae and production of peritonitis. The tumor seldom is the direct cause of death. Cachexia and the resultant death are due primarily to superimposed infective processes. This is especially true in the cæcum, in this region the bacterial fermentation and putrefactive processes reach a maximum of activity. Given the seed for inflammatory reaction, it follows that they will grow rapidly in gut soil already weakened in resistance by malignant degeneration.

We found regional gland metastasis in 25 per cent. of our cases. The ileo-cæcal valve was involved in about 48 per cent. of instances, and one-half of these showed lymphatic invasion. The entire wall was infiltrated in 62 per cent. Ulceration was present in about 40 per cent. Five specimens revealed infiltration of a portion of the appendix. Multiple polyps were present in six instances.

Distant metastasis in other viscera outside of the colon were not discovered. The liver was never found to be the seat of secondary growths. This is in accord with other observers.

*Signs and Symptoms.*—Seldom is the surgeon consulted in the incipency. Rarely do the symptoms manifest themselves before secondary inflammation or obstructions occur.

This fact is clearly demonstrated by our series in which the earliest duration of symptoms was given as ten days. In delving into the past history, however, the patient admitted having had indefinite pain in the right lower quadrant for four years, melena irregularly for one year, and loss of ten to fifteen pounds in weight during that period.

He appeared before me two days after an acute attack of pain, nausea, vomiting and detection of a mass six cubic centimetres in diameter in the right abdomen. At operation a very extensive carcinomatous process was found. The tumor began in the cæcum, involved the valve and extended into the proximal portion of the colon. The lumen was filled with ulcerated papillary projections and the entire wall infiltrated by the growth.

The longest duration of symptoms was fifteen years. This patient had complained of mild "stomach trouble" for that length of time. Three weeks previous to admission he had noticed a mass and then had consulted a surgeon. The average duration of symptoms was one and one-half years to two years.

The symptoms are actually due to secondary complications and may be divided into subjective and objective signs.

*A. Subjective Signs.*—We include in this group: Pain, constipation alternating with diarrhoea, distention, nausea, vomiting and weakness.

*Pain.*—Admittedly a late symptom was present in 80 per cent. of our cases. About one-half of the number maintaining it to be the first indication of disease. It was described usually as a gradual onset of a dull ache. The

location most often mentioned was the right side, chiefly the right lower quadrant or just to the right of the umbilicus. Radiation was inconstant, either absent or down the right leg or toward the umbilicus. Food held no relationship to it. Pain increased in severity during the night hours. Evacuation of the bowels gave the most relief. The pain beginning gradually as a dull ache, steadily increased in character to colicky attacks and sharp piercing qualities. This development may be due to various phases of pathology. Beginning with ulceration through obstruction and to the penetration of the peritoneal nerves by the tumor mass.

Constipation, increasing in severity, was declared the next most frequent symptom. Alternating diarrhoea was mentioned in only three instances, which leads us to conclude that it is not as characteristic of caecal tumor growths as it is of tumors more distal in the colon.

Distention, nausea and vomiting, all signs of degrees of obstruction, occurred with about equal frequency in about one-third of the cases observed.

Weakness and anorexia was present in approximately the same number.

*B. Objective Signs.*—In this group we include loss of weight, presence or absence of mass, tenderness, melena, stiffening of gut, visible peristalsis and anaemia.

Loss of weight was present in about 79 per cent. of instances, varying in amount from five to thirty pounds. Associated with this, there was severe weakness and anaemia. The average haemoglobin reading being 69 per cent.; the red cells numbered three million nine hundred thousand. About an equal number of cases showed either a corresponding diminution in the white cell count or a slight leucocytosis seldom exceeding eleven thousand. A mass was found in one-half of the cases, usually fixed to a degree posteriorly. With one exception tenderness was always elicited when a mass was present.

Melena, a rather constant finding in tumors higher in the colon, was present in one out of four cases. A search for occult blood should be made, though, as aforementioned, we feel that a positive finding is less frequent in caecal growths.

Stiffening of the gut, excluding masses found, and visible peristalsis were noted frequently.

In addition to the above signs and symptoms we have the aid of the Röntgen-ray. It is impossible not to regard Röntgen-ray examination of paramount importance in suspected caecal disease. Unquestionably in the detection of early involvement it stands first in value as an aid in diagnosis.

In our series, in every case subjected to Röntgen examination, either with the preliminary barium meal or the colon enema, caecal pathology was discovered and in the vast majority of instances, an accurate diagnosis was made pre-operatively.

The usual findings in caecal carcinoma were a filling defect or a change in the normal contour. A lack of contrast mixture in the caecum was a frequent finding. Absence of peristalsis in the caecum with hypermotility

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in the colon was a very constant picture. In addition, distention of the distal loops of ileum was found with varying degrees of obstruction.

*Operation.*—We prefer the Friedrick operation for tumors of the right side of the colon and consequently have performed this technic in twenty-seven of the cases reported. It consisted of the removal of ten to twelve inches of the ileum, the entire cæcum, the ascending colon and from one-third to one-half of the transverse colon, completed by an anastomosis of the ileum to the transverse colon, end-to-end being the choice. A side-to-side anastomosis is the operation of choice in the very fat endowed colon. End-to-side anastomosis was done in three of the recorded cases.

We have not had occasion to use the methods of precaution against gas distention as advocated by Dr. Charles Mayo.

Results following the Friedrick technic have justified our preference for it. Of the 28 cases we had six deaths, or a mortality of 21.4 per cent. The post-operative convalescence was relatively easy, and the follow-ups were satisfactory.

Ileo-colostomy was resorted to on four occasions. One with anastomosis of ileum to transverse colon, three ileum to sigmoid. One patient had had an ileo-sigmoidostomy made six months previously which was not disturbed at the second operation, where removal of the growth was done. On two occasions the growth was not resected, only a palliative short circuit was attempted. One recent recurrence from another city—two years after operation with obstruction. (Collor.) An ileo-sigmoidostomy done.

A delivery of the tumor after the method of Mikulicz and subsequent closure of the artificial anus, resulted in one death out of two cases.

Four instances of complete intestinal obstruction rendered resection impossible and a temporary ileostomy was made with a Paul's tube inserted into the ileum, resulting in two deaths.

A plastic on the cæcum with local resection of a benign tumor was done in one instance and resulted in permanent cure. This is not added to the total number.

We were unable to find the type of operation done in one case with carcinoma complicated by obstruction, which resulted in a mortality. In two instances appendectomies had been done within a period of five years and both patients stated that they had not been feeling well since that time. At operation in each instance the growth was very extensive. This might suggest the possibility of an early tumor presenting the symptoms of an inflamed appendix and having been overlooked. Attention to such has been cited by John F. Erdmann.

Another case had had a resection of a portion of the transverse colon eight years before, and was entirely well until six months before we had an opportunity to see him. At operation an extensive colloid carcinoma was found with regional glandular metastases. Moreover, in the colon, forty-nine centimetres from the cæcal growth, a nodule twenty-five by ten millimetres was found to be of similar pathology. Here again, since we know



that colloid carcinoma is sluggish in growth, we may infer that the caecal tumor might have been present and passed unnoticed by the operator.

#### SUMMARY

Forty-eight cases of caecal tumor were studied. Carcinoma was found in thirty-seven instances, tuberculosis in seven, chronic inflammation in two and lympho-sarcoma in one; one undetermined.

Other tumors occasionally found are cyst, gummas, lipomas, tuberculomas, papillomas, cholesteatomas, leiomyomas and actinomycosis.

The ileo-caecal region is the site of predilection for tuberculosis, because of the right lymphatic supply.

Three of the seven tuberculosis cases were of the hyperplastic type without a demonstrable primary focus. The fourth had an involvement of the right lung and the caecal growth was considered to be secondary. Three others were tuberculomas.

The Friedrick resection was performed in all the tuberculous tumors, with no mortality and a symptomatic cure. Only appendectomy was done in three tuberculomas.

The caecum has a predisposition to malignant degeneration because of its physiological and anatomical relationship.

Regional glandular metastasis was found in 25 per cent. of the cases reported. The ileo-caecal valve was involved in 48 per cent.

The signs and symptoms most frequently found were pain, loss of weight, a mass and marked anaemia. Röntgen examination was the most accurate aid in diagnosis.

The Friedrick operation was the method of choice, being performed in twenty-eight of the thirty-seven cases of carcinoma, with a mortality of 21.4 per cent.

#### CONCLUSION

Carcinoma is the most frequent caecal tumor requiring surgical intervention. Lympho-sarcoma is the most highly malignant tumor.

Caecal carcinoma are slow growing and only moderately malignant. Secondary infection invades the tumor early and is the chief cause of the profound cachexia found in these cases.

Distant metastases are rare in carcinoma of the caecum.

Secondary intestinal growths are not uncommon and should always be sought for. A malignant tumor obstruction may simulate a chronic appendicitis.

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THE ADVANTAGES OF A LOW MEDIAN-LINE INCISION  
IN EXPLORATORY LAPAROTOMY FOR CARCINOMA  
OF THE RECTUM OR RECTOSIGMOID\*

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IN 1918 I presented before this association a paper recommending exploration of carcinomas of the rectum and rectosigmoid through a left rectus incision and the making of a colostomy through this incision similar in type to that previously described by Mixter. Since then this type of colostomy has been used many times in the Mayo Clinic and has been satisfactory in all except in one particular. However, following such an operation several patients developed intestinal obstruction caused by a loop of small intestine slipping down between the loop of sigmoid, which had been lifted up in performing the colostomy, and the left lateral wall of the abdomen.

In order to avoid this serious complication I have for some time explored growths in this region through a low median-line incision, and whenever colostomy was thought best I have performed it through a separate incision. Such an operation seems to have distinct advantages.

Through a low median-line incision it is easy to make a satisfactory examination of the abdominal cavity for evidence of metastasis in the liver, lymph-nodes, and other structures, and if one wishes, to perform primary resection, a Jones operation or a Coffey operation. Should a two-stage operation be preferable, as is often the case, a Mikulicz type of operation for growths in the sigmoid loop may easily be performed through the low median-line incision. If colostomy and subsequent posterior resection seem indicated, the loop of bowel selected for the colostomy may be carefully examined, and freed from any adhesions and then brought out by way of a separate incision through the abdominal wall; it may be placed at the point desired and close enough to the lateral abdominal wall to prevent the small intestines from slipping between them.

In such cases I have usually performed the colostomy through a gridiron incision placed close to the crest of the ilium on the left side. With one hand in the abdominal cavity as a guide, one can quickly make an opening in the abdominal wall just large enough to permit the loop of bowel for the colostomy to be brought through (Fig. 1). The loop brought out is supported by a strip of skin or a glass rod which is passed through an opening in its mesentery (Fig. 2).

In some patients with growths in the upper rectum, but still above the peritoneum in the bottom of the cul-de-sac, we have made a temporary stoma of the sort mentioned and later resected the growth and made an end-to-end anastomosis and still later closed the stoma. If a temporary stoma is made,

\* Read before the Southern Surgical Association, December 14, 1926.

# LAPAROTOMY FOR CARCINOMA OF THE RECTUM

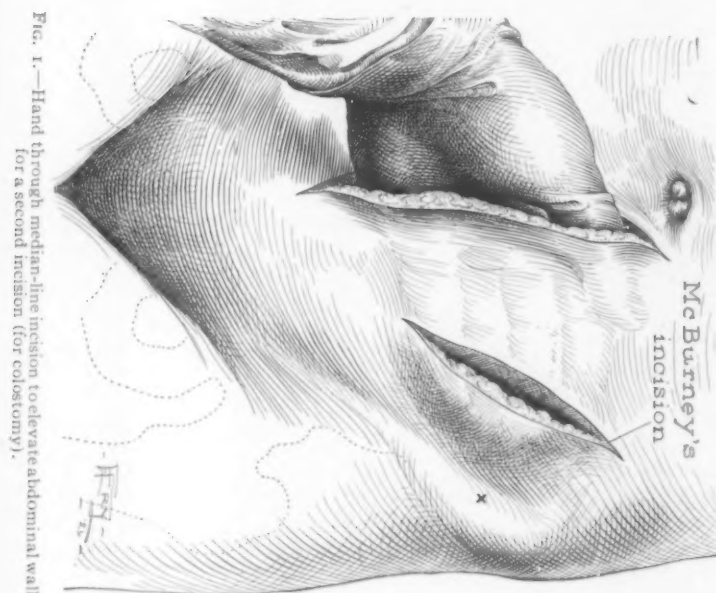


FIG. 1.—Hand through median-line incision to elevate abdominal wall for a second incision (for colostomy).

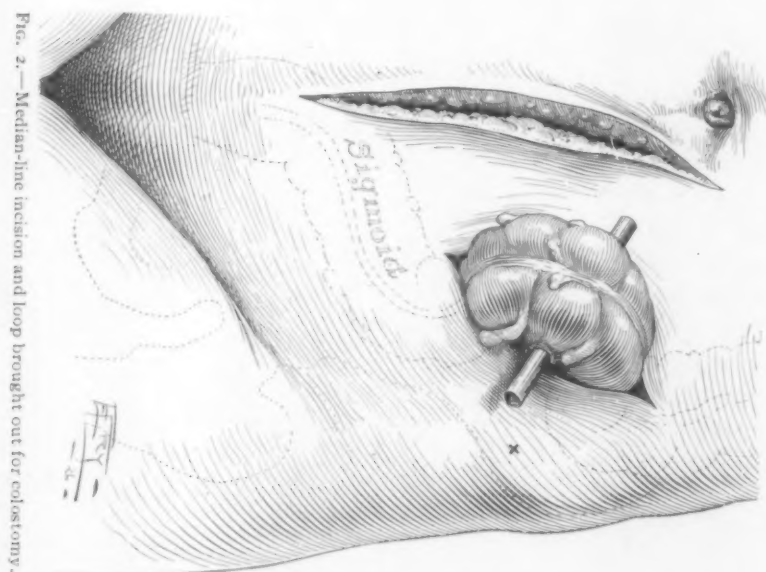


FIG. 2.—Median-line incision and loop brought out for colostomy.

the limbs of the bowel may be sutured together as suggested by Coffey, and closed by applying clamps, and so forth, as is done in completing a Mikulicz type of operation (Fig. 3).



FIG. 3.—Loop brought out through median-line incision for Mikulicz type of operation.

It is necessary when performing colostomy to remember that the loop of bowel used should be brought out of the abdominal wall far enough to allow it to be cut completely across; otherwise the upper segment of bowel will often empty its contents into the lower one. In certain stout patients with thick abdominal walls the mesentery of the sigmoid is so short and wide that it is impossible to bring a knuckle of bowel entirely

through the abdominal wall without great tension; not only is colostomy performed under such circumstances dangerous, because of possible gangrene of the bowel from tension, but the stoma often fails to function properly. In such cases I have found it much safer to extend the median-line incision upward an inch or two (Fig. 4) and to make a stoma from a loop of the transverse colon. After the colostomy has been completed, the median-line incision may be closed and dressed separately from the colostomy wound. In practically all cases the wound from the incision heals primarily.

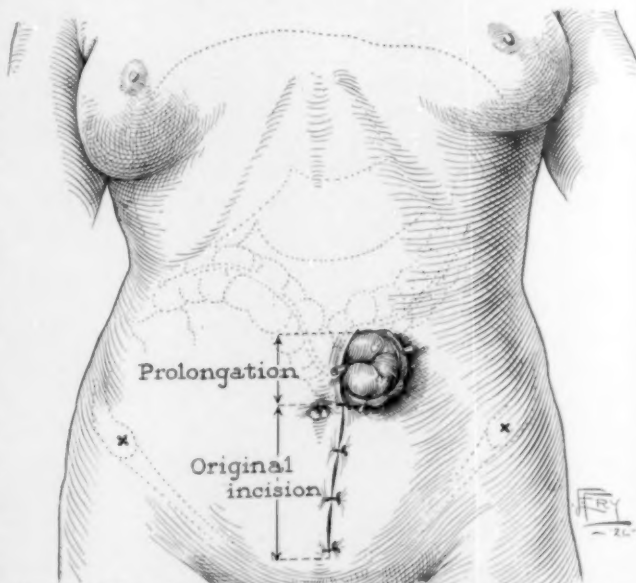


FIG. 4.—Median-line incision prolonged for colostomy in transverse colon.



## CLASSIFICATION OF RENAL AND URETERAL ANOMALIES<sup>1</sup>

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OUR object is to attempt to classify in as complete a manner as possible all the various anomalies of the upper urinary tract. In place of a lengthy description, we prefer to illustrate the different groups in a diagrammatic way, and limit the description as much as it can be done.

We classify the anomalies as follows:

### A. *Anomalies of the Kidneys.*

#### 1. *Anomalies of Number.*

- a. Solitary kidney (Figs. 1 and 2).
- b. Supernumerary kidney (Fig. 3).

#### 2. *Anomalies of Volume.*

- a. Hypoplasia (Fig. 4).
- b. Supplementary lobe (B of Fig. 5) or hypertrophy (A of Fig. 5).

#### 3. *Anomalies of Form.*

Short, long, lobulated kidneys (Fig. 6).

#### 4. *Anomalies of Location.*

- a. Simple or ordinary unilateral ectopia (A of Fig. 7).
- b. Simple or ordinary bilateral ectopia (B of Fig. 7).
- c. Crossed ectopia with or without fusion (Figs. 8 and 8A).

#### 5. *Median Fusion.*

- a. Horseshoe kidney (Figs. 10 and 11).
- b. L-Shaped kidney (Fig. 11).
- c. Cake kidney (D of Fig. 10).
- d. Sigmoid kidney (C of Fig. 11).

#### 6. *Anomalies of Rotation.*

- a. Faulty rotation (A of Fig. 12).
- b. Excessive rotation (B and C of Fig. 12).

#### 7. *Reduplication of the Pelves and Ureters* (Figs. 13, 14, 15).

#### 8. *Anomalies of the Pelvis* (other than reduplication). (Figs. 16 and 17).

#### 9. *Anomalies of the Vessels* (Figs. 18, 19, 20).

- a. Arteries (Figs. 18 and 19).
- b. Veins (Fig. 20).

#### 10. *Nonclassifiable Anomalies* (Fig. 21).

### B. *Anomalies of the Ureters.*

#### 1. *Anomalies in Number* (See A 7) (Figs. 13, 14 and 15).

#### 2. *Anomalies of Calibre and Form.*

- a. Congenital strictures (Fig. 22).
- b. Congenital dilatation (Fig. 23).
- c. Valves (Fig. 24).
- d. Spiral twists and kinks (Fig. 25).

<sup>1</sup> This is the first chapter of the monograph on Renal and Ureteral Anomalies to be published shortly.

3. *Anomalies of Origin or Termination.*

- a. Abnormal modes of origin.
  - b. Ureteroceles or cystic dilatation of lower end (Fig. 26).
  - c. Blind ending ureters (Fig. 27).
  - d. Ectopic ending of the lower end (Fig. 28).
4. Diverticula of the ureter (Figs. 29 and 30).

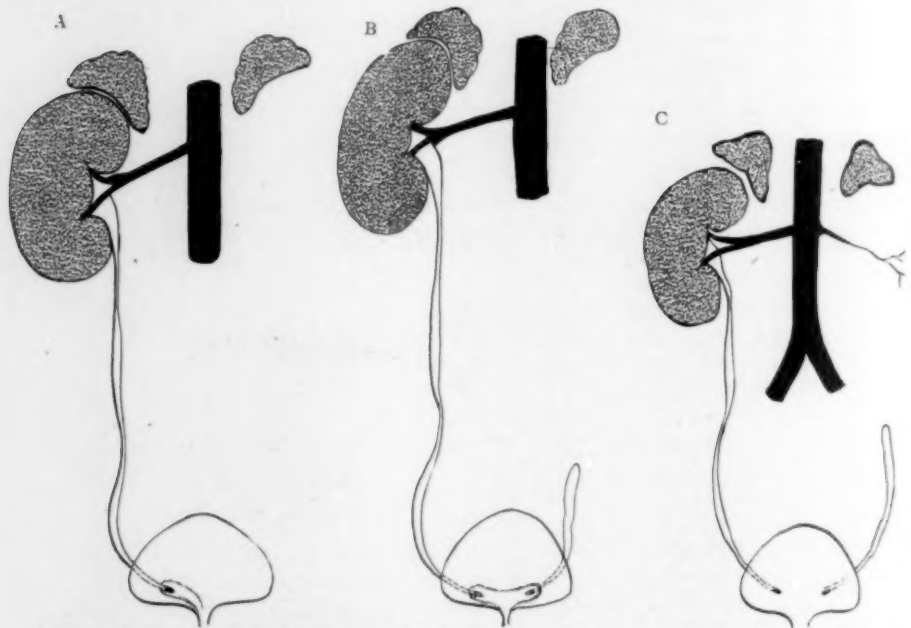


FIG. 1.—A, Absence of kidney, ureter and ureteric orifice. Asymmetric trigone. B, Absence of kidney but rudimentary ureter with normally placed and formed ureteric orifice, and symmetric trigone. C, Same as B, but with rudimentary renal artery.

C. *Combined Anomalies.*

1. Double kidney and abnormal ending ureters (Fig. 31).
2. Double and horseshoe kidney (Fig. 32).
3. Vascular anomalies and renal anomalies.
4. Ectopia and horseshoe kidney (Fig. 33).
5. Hypoplasia and double kidney.
6. Hypoplasia and horseshoe kidney.

D. *Concomitant Anomalies* (Fig. 34).

- a. Of urinary tract.
- b. Of genital tract.
- c. Of other structures.

Let us consider these a little in detail:

A. I. ANOMALIES OF NUMBER OF KIDNEYS

We will omit bilateral absence of the kidneys, which is a monstrosity incompatible with life.

The number of kidneys can either be decreased or be in excess.

(a) *By Default (Absence).*—Under this heading should be placed the congenital solitary kidney. The term should only be employed when there

# RENAL AND URETERAL ANOMALIES

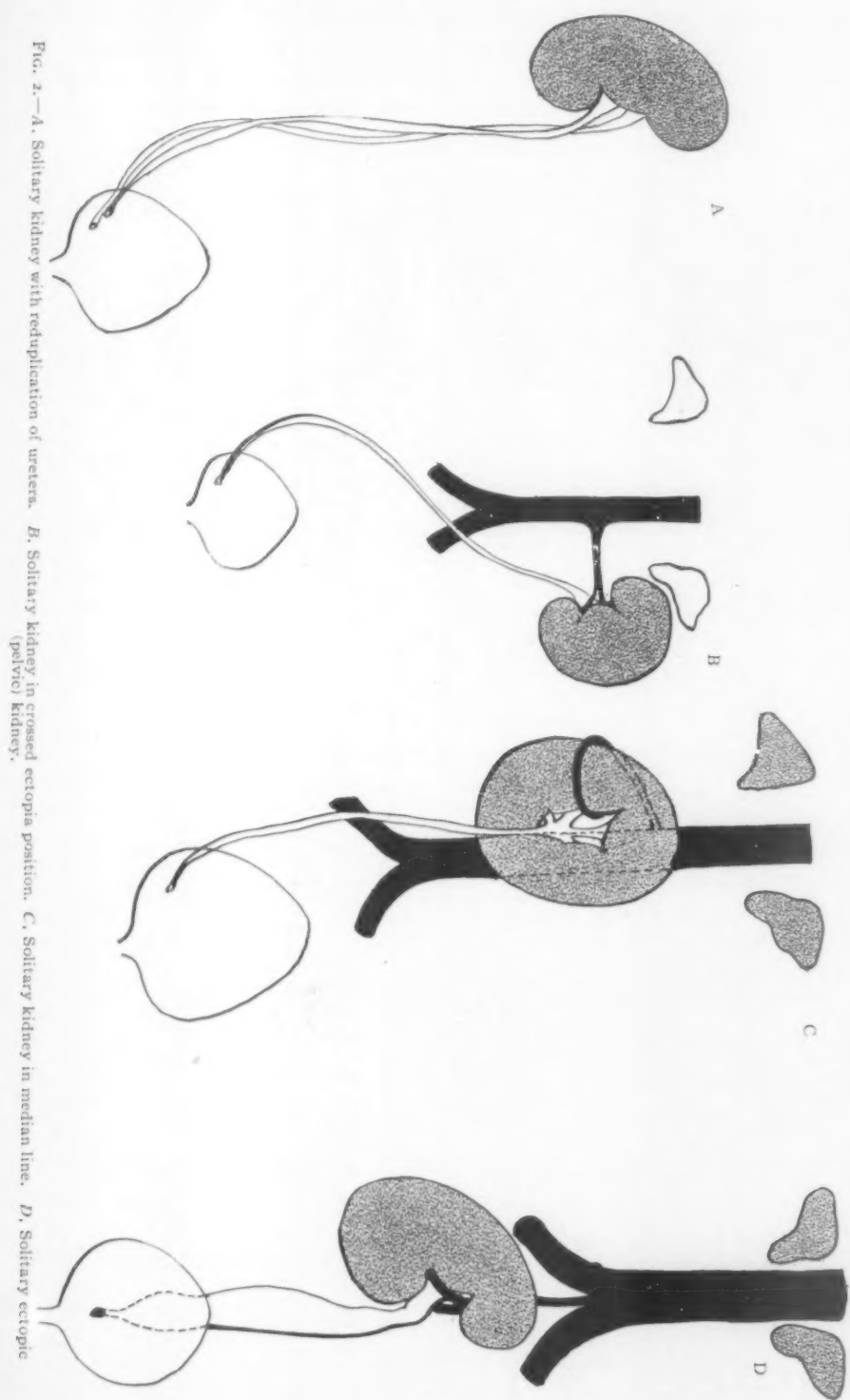


FIG. 2.—A. Solitary kidney with reduplication of ureters. B. Solitary kidney in crossed ectopia position. C. Solitary kidney in median line. D. Solitary ectopic (pelvic) kidney.

are no traces of the opposite kidney. Congenital agenesis or aplasia are synonymous with congenital solitary kidney. One should not confuse the condition with unilateral fusion of two kidneys each having a ureter which ends at opposite ends of the trigone. The term crossed ectopia is a more correct one to apply to such an anomaly (Fig. 8).

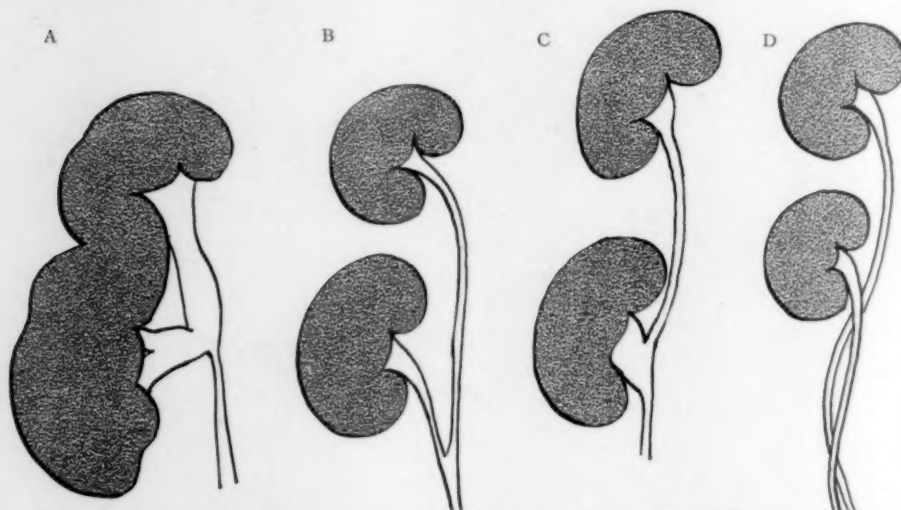


FIG. 3.—Reduplication and supernumerary kidney. A, Reduplication of pelvis alone with partly divided kidney. B, Reduplication (incomplete) of ureter and completely separated kidneys. D, Reduplication (complete) of ureter and completely separated kidneys. C, Most common form of supernumerary kidney. Upper ureter empties into lower pelvis or ureter of lower (supernumerary) kidney.

There are three principal types of solitary kidney:

1. With symmetric or asymmetric trigone (A of Fig. 1). No trace of opposite kidney or ureter.

2. With symmetric trigone, two ureteral orifices and a ureter on the agenesis side which is of variable length (B of Fig. 1).

3. With more or less developed ureter on the agenesis side and rudimentary renal vessels (C of Fig. 1).

The solitary kidney may be of normal or of increased volume. The adrenal on the agenesis side is either in its normal location or ectopic. One may encounter some atypical conditions, such as:

1. Solitary kidney with two ureters ending side by side in the bladder (A of Fig. 2).

2. Solitary kidney in crossed ectopia (B of Fig. 2).

3. Solitary kidney in median ectopia (C of Fig. 2).

4. Solitary kidney and pelvic ectopia (D of Fig. 2).

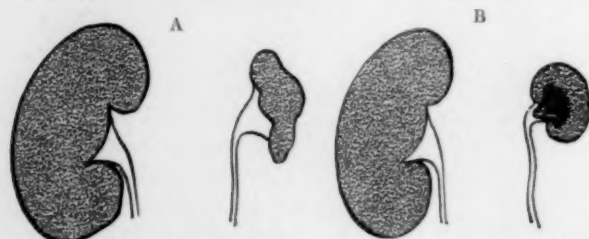


FIG. 4.—A, Congenital hypoplasia or atrophy. B, Congenital hypoplasia with single papilla.

## RENAL AND URETERAL ANOMALIES

b. *Multiple Kidneys, i.e., Excess (Supernumerary)*.—These are rare and one must consider four forms:

1. Pseudo-double kidney, *i.e.*, single mass of parenchyma but two pelves and a single ureter (A of Fig. 3).

2. Two kidneys with two ureters uniting to form a single ureter (B of Fig. 3).

3. Same as above but the two ureters open separately into bladder (D of Fig. 3).

4. Two kidneys but ureter of upper opens into lower (C of Fig. 3). (Most common form of supernumerary kidney).

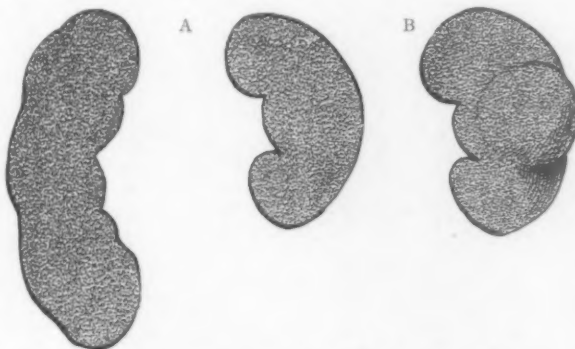


FIG. 5.—A, Congenital hypertrophy of one kidney. B, Supplementary anterior lobe.

Numbers 1, 2, and 3 are rare and the only published cases are unilateral.

### A. 2. ANOMALIES OF VOLUME

(a) *Congenital Atrophy or Hypoplasia*.—The two normal kidneys are seldom of the same weight or volume. The ureter of an atrophic kidney is usually patent. It can be dilated or obliterated either at its upper or lower end, or at portions of its course, or in its entirety.

(b) *Congenital Hypertrophy*.—The kidney can be hypertrophied compensatorily because the opposite one is atrophic, but it can also be enormous while the opposite one is normal, as in Papin's (A of Fig. 5) case.

(c) *Supplementary Lobes*.—In Papin's case this formed a marked pro-

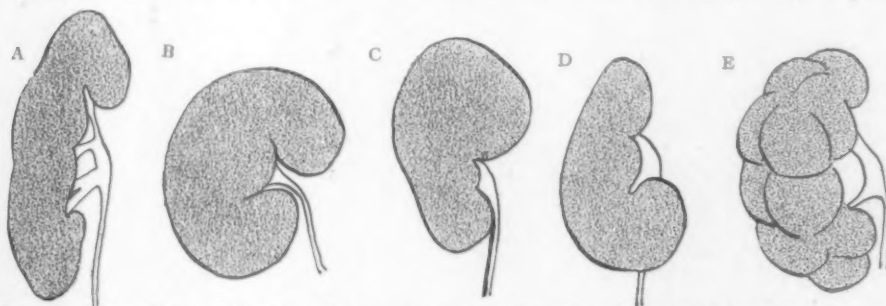


FIG. 6.—A, Long kidney with wide pedicle. B, Short kidney with deep hilus. C, Kidney with large upper half. D, Kidney with large lower half. E, Kidney with fetal lobulation.

trusion (B, Fig. 5) on the anterior surface. On section one found one pyramid and a corresponding calyx directed sagittally.

### A. 3. ANOMALIES OF FORM OF KIDNEYS

There are many variations in form, thus:

(a) Long kidney with wide pedicle (A of Fig. 6).

(b) Short kidney with closed hilus (B of Fig. 6).



- (c) With large upper half (C of Fig. 6).
- (d) With large lower half (D of Fig. 6).
- (e) With fetal lobulation (E of Fig. 6).

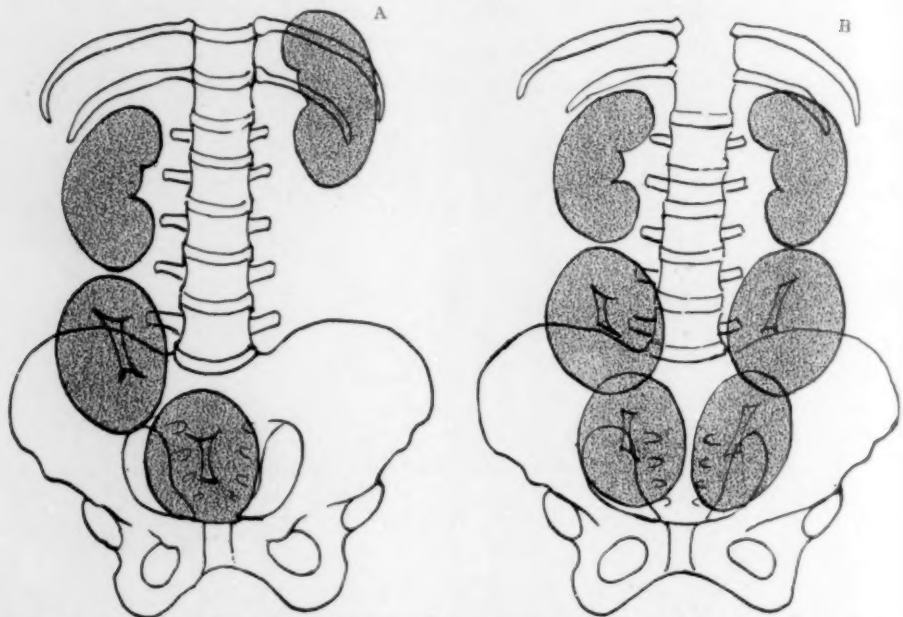


FIG. 7.—A, Simple or ordinary (unilateral) ectopia, lumbar, iliac, pelvic. B, Simple or ordinary (bilateral) ectopia, iliac, pelvic.

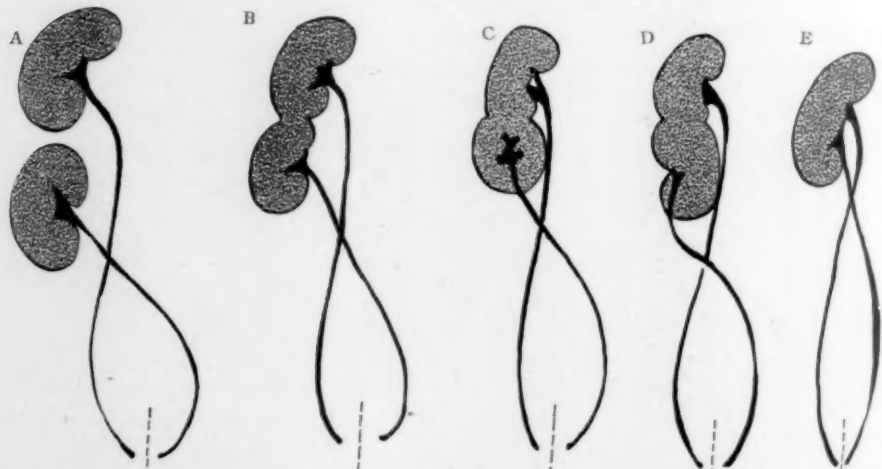


FIG. 8.—Crossed ectopia. A, Completely separated kidneys. B, Fusion of both kidneys (to right or left of midline as indicated by vertical dotted line). C, Hilus of lower of the two incompletely fused kidneys faces ventrally. D, Same as C, but lower hilus faces laterally. E, Complete fusion of the two kidneys.

#### A. 4. ANOMALIES OF POSITION OF KIDNEYS

1. The kidney can be found in an abnormal location either by arrest or faulty development. One must differentiate them from the kidneys whose abnormal location is of acquired origin. Ectopia can be lumbar, iliac or pelvic

## RENAL AND URETERAL ANOMALIES

(Fig. 7, A) or it can be unilateral or bilateral (Fig. 7, B). The last named may be symmetric or asymmetric in position. All such ectopias are called homolateral.

2. Heterolateral or crossed ectopias are where one of the two kidneys has crossed the midline to reach the opposite side. There are three forms:

(a) The kidneys are not fused (A of Fig. 8).

(b) The kidneys are fused but the line of fusion is still distinct. The lower of the two may have its pelvis directed mesially (B of Fig. 8), ventrally (C of Fig. 8) or laterally (C of Fig. 8).

(c) The two are fused so that there is no external sign of such fusion (E of Fig. 8). As a rule it is the lower of the two which is ectopic, but in some it is the upper (F of Fig. 8). The case of Lichtenstern of bilateral crossed ectopia (G of Fig. 8) is open to question.

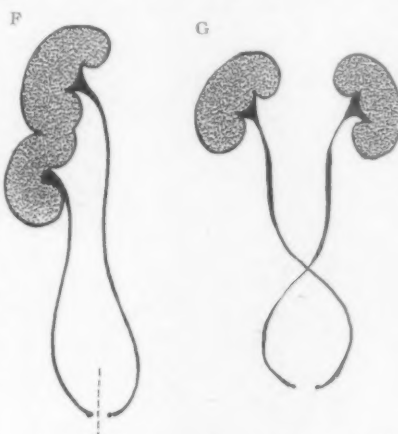


FIG. 8.—F, Unusual condition in which the ectopic kidney which belongs to opposite side of body lies above the normally migrated kidney. G, Unusual condition in which right kidney has crossed over to left side of body and vice versa.

### A. 5. MEDIAN FUSION

We include in this group all cases in which there is a union of the two

kidneys to a greater or lesser extent at their mesial borders. As long as one-half extends beyond the midline of the spine, the anomaly belongs in this group. When, however, both halves lie entirely either to the right or left of the midline of the spine, the anomaly is better classified as a crossed ectopia (Fig. 8). The true cases of median fusion therefore include other cases than those usually referred to as horseshoe kidneys. In the latter the degree of median line fusion varies from a nar-

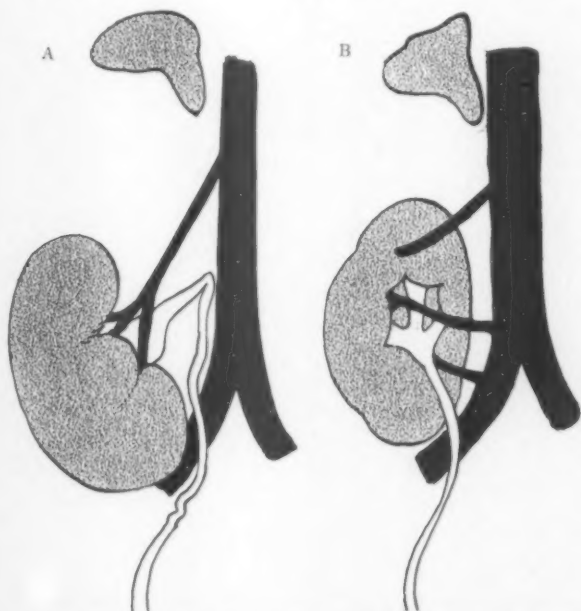


FIG. 9.—To show difference between an abnormally mobile (dropped) and a congenitally (simple or ordinary) ectopic kidney. In the former the vessels arise (A) at the normal level while in latter (B) they arise from the immediately adjacent vessels.

row fibrous or parenchymatous bridge to complete fusion along the mesial borders, *i.e.*, a cake-kidney. Cases, however, of L-shaped or S-shaped (sigmoid) kidneys in which one-half extends beyond the midline should be equally as well classified under the heading "Median Fusion." All such anomalies lie much lower than the normally formed and placed kidneys. Their

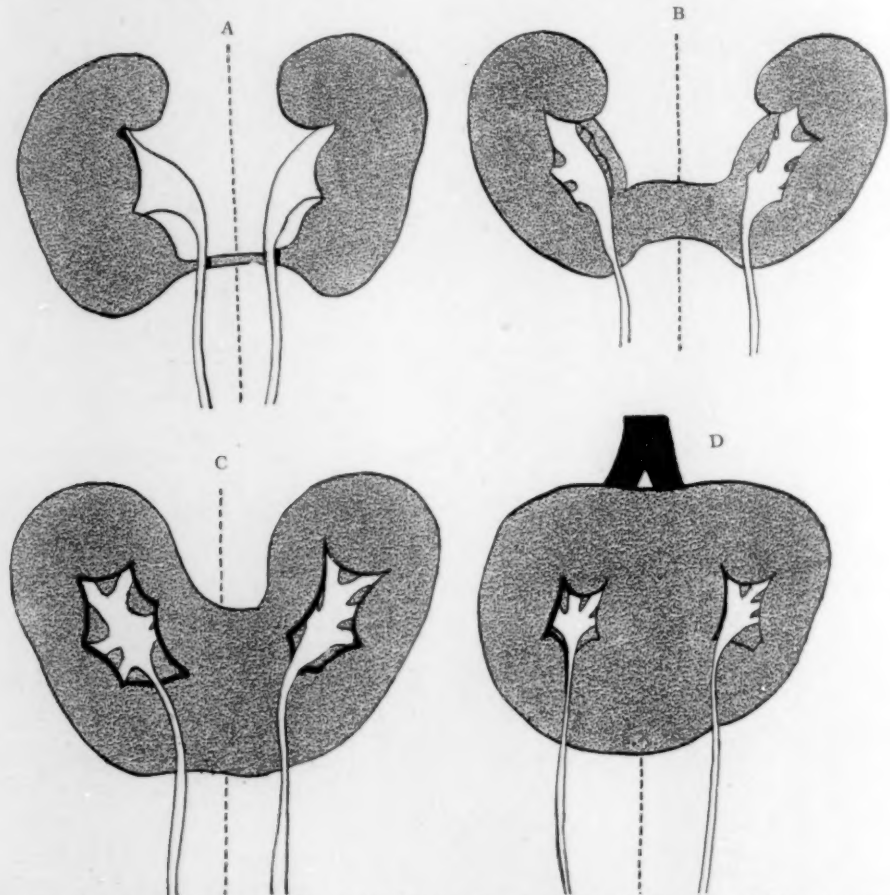


FIG. 10.—Horseshoe kidneys with inferior isthmus (90 per cent. of all cases). A, With very narrow isthmus. B, With isthmus of average (4–5 cm.) width. C, With very wide isthmus. D, With isthmus so wide that there is no line of demarcation between the two halves (the so-called cake kidney).

pelves, however, are on the ventral aspect, a point of much importance from a diagnostic standpoint. We may, therefore, find the following forms:

1. Fusion of two of the poles.
  - (a) Inferior (narrow, median and wide isthmus) (A, B and C of Fig. 10).
  - (b) Completely along their mesial border (D of Fig. 10) (cake kidney).
  - (c) Superior isthmus (A of Fig. 11).
2. Sigmoid (C of Fig. 11), one in normal location and the other attached to lower pole of first one.
3. One remains higher than the other (L-shaped) (B of Fig. 11).

## RENAL AND URETERAL ANOMALIES

### A. 6. ANOMALIES OF ROTATION OF KIDNEYS

(a) Incomplete—kidney faces ventrally, it is flattened and pelvis is at middle of anterior surface, vessels cross the front to reach the hilus and the ureter descends in front of kidney (A of Fig. 12).

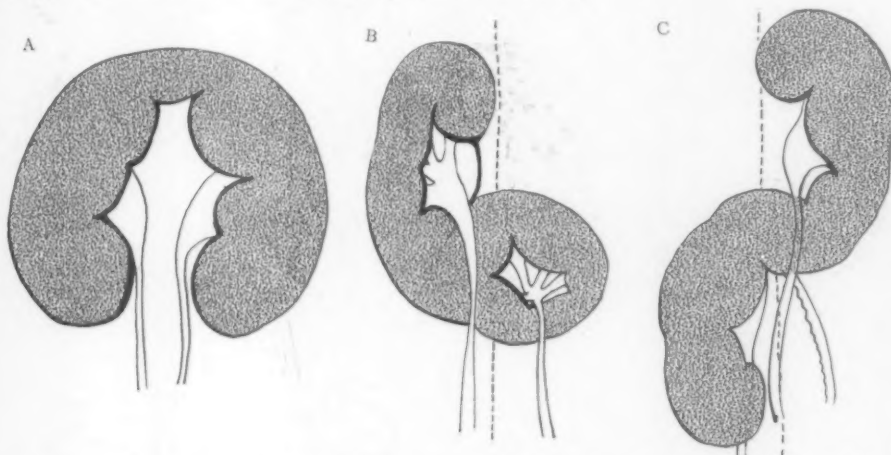


FIG. 11.—Unusual types of horseshoe kidneys. A, With isthmus at upper poles (10 per cent. of all cases). B, L-shaped horseshoe kidney. C, Sigmoid form with pelvis facing laterally. Differs from crossed ectopia (Fig. 9) by fact that the halves extend to both sides of midline.

(b) Excessive rotation. Hilus on dorsal aspect and latter is crossed by vessels to reach hilus (B of Fig. 12).

(c) The convex border is mesial and pelvis faces laterally (C of Fig. 12).

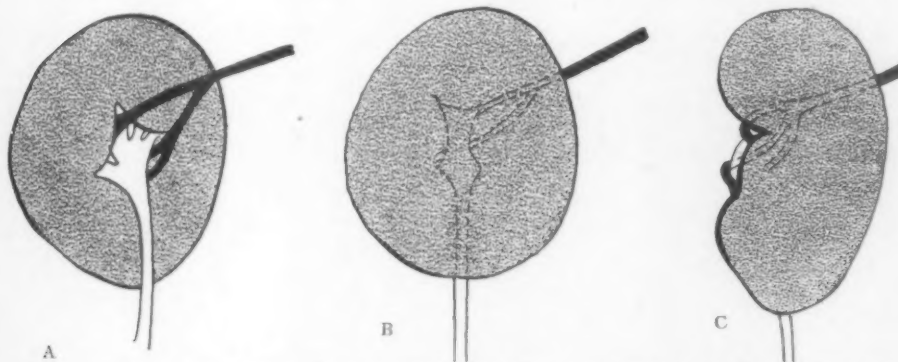


FIG. 12.—Most frequent types of faulty rotation of the kidney (renal torsion). A, Incomplete rotation with hilus on ventral aspect. B, Excessive rotation with hilus on posterior aspect. C, Excessive rotation with hilus facing laterally.

The vessels cross the dorsal aspect and the ureter descends along lateral border.

### A. 7. REDUPLICATION OF THE PELVES AND URETERS (DOUBLE KIDNEY) (FIGS. 13, 14 AND 15)

Under normal conditions the ureter divides into two major calyces with or without a pelvis proper. An early division may occur, *i.e.*, one just external to the hilus. The kidney then has two pelvis, an upper and a lower.

The ureter may divide more distally, *i.e.*, anywhere from the hilus to the bladder. If the division occurs within the bladder wall itself there will be

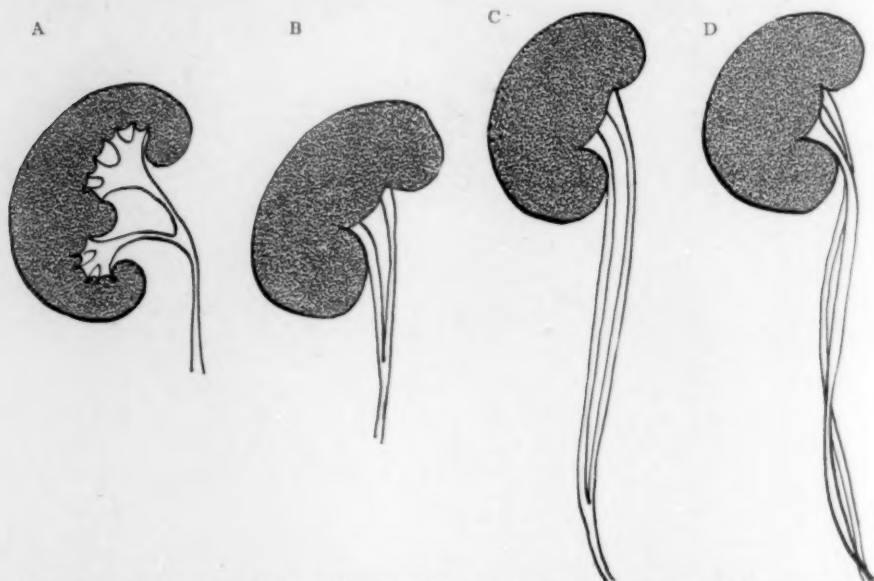


FIG. 13.—Transition from bifid pelvis to double kidney. A, Bifid type of renal pelvis. B, High division of ureter (incomplete reduplication of the ureters but complete of pelvises). C, Low division of ureter (incomplete reduplication of ureters but complete of pelvises). D, Complete reduplication of ureters and of the renal pelvises. In B, C and D there is no external demarcation to indicate a double kidney (compare with B, of Fig. 15).

two ureteral meati and we speak of a double ureter. When there are two ureters one will always find two pelvises. No case has ever been proven to

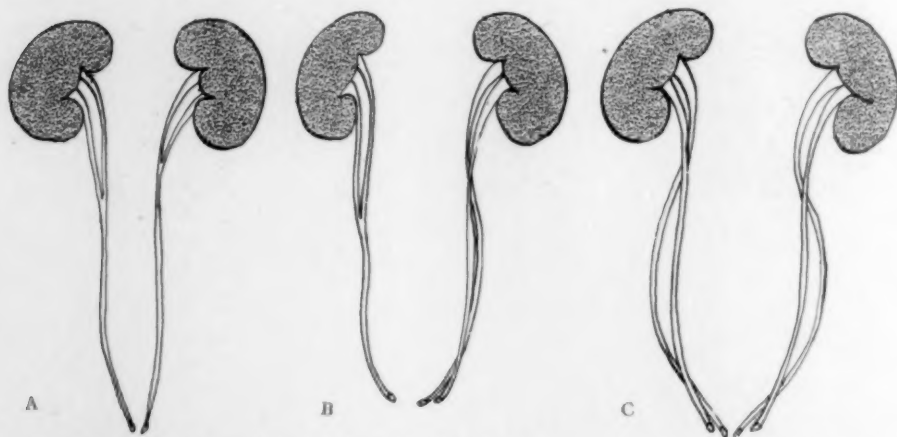


FIG. 14.—Various types of double kidney (unilateral). A, Incomplete (high division) reduplication of the ureters and pelvises of both sides. B, Incomplete (right-sided) and complete (left-sided) reduplication. C, Complete reduplication of ureters and pelvises on both sides.

have two ureters and one pelvis. The ureter belonging to the upper pelvis always ends lower and more mesial.

Reduplication or bifidity of the ureters can be observed in association with



## RENAL AND URETERAL ANOMALIES

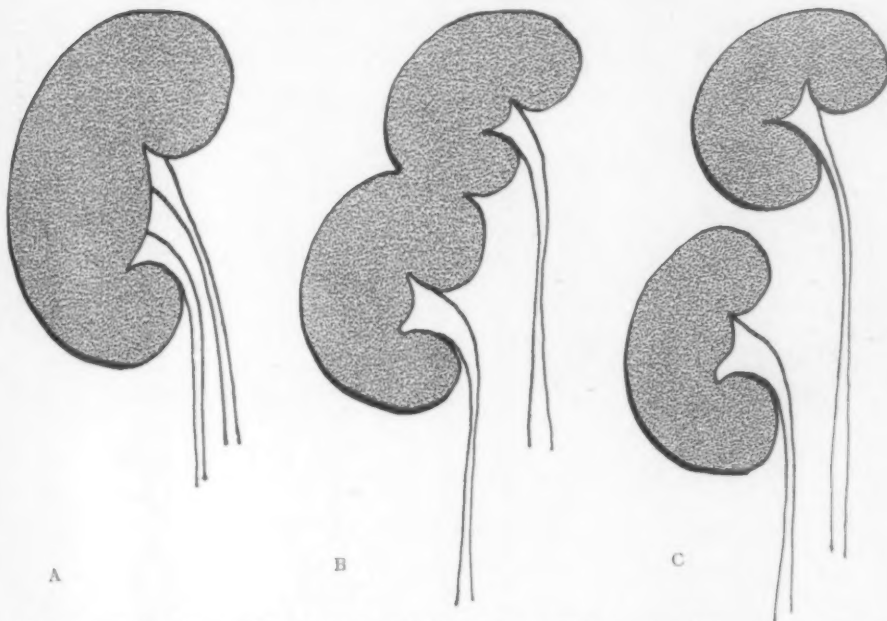


FIG. 15.—Various types of "double kidney" (unilateral). *A*, Without external demarcation (same as *A*, *B* and *C*, of Fig. 14). *B*, With well-marked groove indicating line of fusion of the two halves. *C*, Complete separation of the two halves. This diagram exaggerates the distance between the two pelves and the corresponding parenchyma.

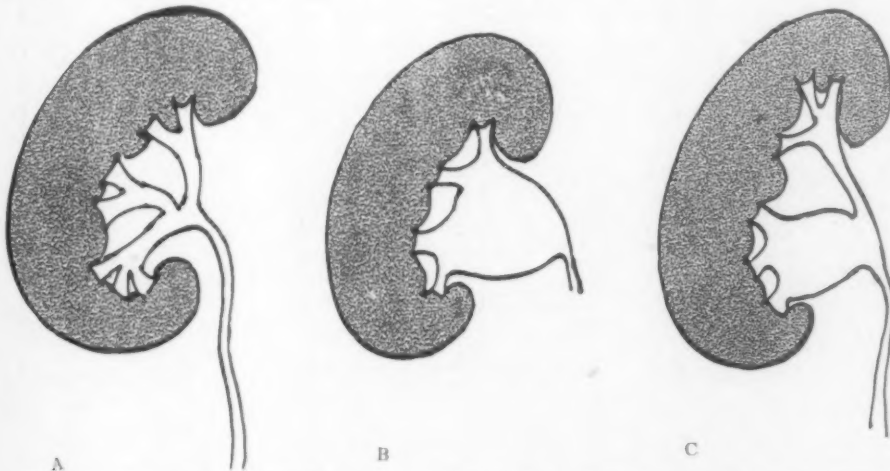


FIG. 16.—Various types of renal pelves. *A*, With relatively small pelvis proper and predominance of major calyces. *B*, Ampullary type of pelvis with typical superior, middle and inferior major calyces. *C*, Peculiar ampullary pelvis with large inferior calyx.

a kidney of normal external appearance (Fig. 13). Ureteral reduplication can be unilateral or bilateral (Fig. 14, *A*, *B*, and *C*).

### A. 8. ANOMALIES OF THE PELVIS

Pelvis can present many variations which are not anomalies in strict sense.

(a) The pelvis proper is absent. The ureter divides into major calyces without an intervening pelvis (*A* of Fig. 16).

(b) An ampullary pelvis into which the minor, *i.e.*, secondary calyces empty without intervening major calyces (B of Fig. 16).

(c) A bifid type (hemibassinet of Hyrtl). One of the major calyces (the inferior) is dilated and ampullary while the other has a number of calyces (C of Fig. 16).

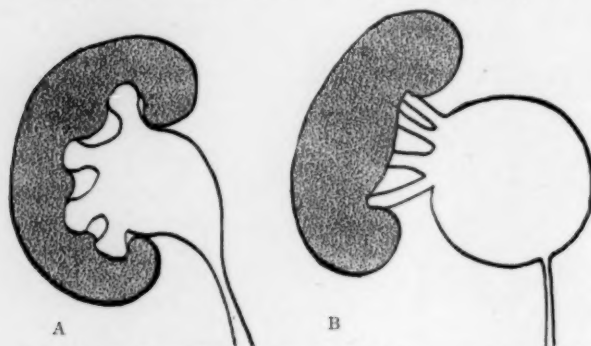


FIG. 17.—A, Congenital hydronephrosis without ureteral or other distal obstruction. B, Pelvis and major calyces entirely extrarenal.

(b) The extrarenal pelvis (B of Fig. 17). Both the pelvis proper and most if not all of the major calyces are extrarenal, *i.e.*, lie distal to the hilus of the kidney.

#### A. 9. ANOMALIES OF THE VESSELS OF THE KIDNEYS

1. *Arteries*.—These are very common (see Figs. 18 and 19). Under normal conditions there is a single artery arising from the aorta and dividing in variable manner into three terminal branches, pre- and retro-pelvic and superior polar. The anomalies may be grouped as follows:

(a) Of number—from one to six arteries have been noted.

(b) Of origin—aorta, spermatic, common iliac, external and internal iliac.

(c) Of course—in front and behind aorta and vena cava.

(d) Of penetration—hilus, pole, front borders. Of particular interest are the polar arteries. The superior polar can arise from the renal or aorta. The inferior polar can arise from the renal, aorta, common or external iliac. The inferior polar may cross in front or behind the ureter and may cause or aggravate a hydronephrosis.

2. *Veins*.—Among the more important anomalies one finds (see Fig. 20):

(a) Presence of a left inferior vena cava.

(b) Retro-colic venous anastomosis.

(c) Superior polar.

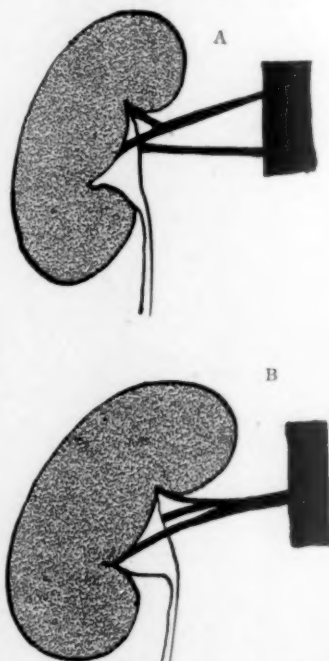


FIG. 18.—Types of renal arteries. A, Division before reaching renal hilus. B, Two separate renal arteries.

## RENAL AND URETERAL ANOMALIES

(d) Inferior polar—more common and can arise from the vena cava, renal vein and iliac vein.

(e) Renal vein entirely retroperic.

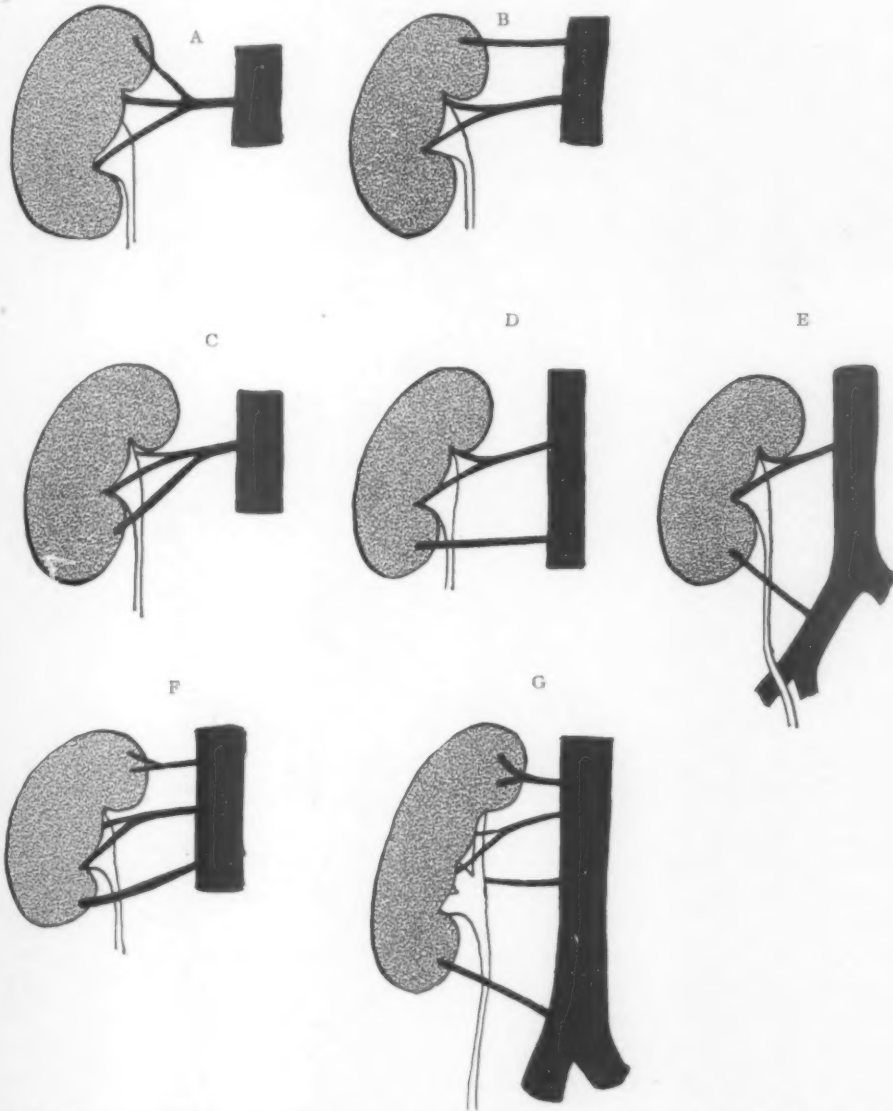


FIG. 19.—Anomalous (accessory) polar arteries. *A*, Superior polar arising from main renal artery. *B*, Superior polar artery arising from aorta. *C*, Inferior polar artery arising from main renal. *D*, Same arising directly from aorta. *E*, Same arising from common iliac artery. *F*, Main renal artery to hilus and superior and inferior (also from aorta) arteries to upper and lower poles respectively. *G*, Same as *F*, but separate (fourth) artery to back of pelvis.

### A. 10. NON-CLASSIFIABLE ANOMALIES (FIG. 21)

Under this heading one must place the cases of Hepburn and Braasch. The ureters of the two normally placed kidneys unite and end at one angle of the trigone.

B. ANOMALIES OF THE URETERS

*B. 1. Anomalies of Number.*—These are described under reduplication of the renal pelvis (see A 7), because such a condition is never found without reduplication of the ureters to a greater or lesser degree.

*B. 2. Anomalies of Calibre and Form.*—The ureter normally presents a

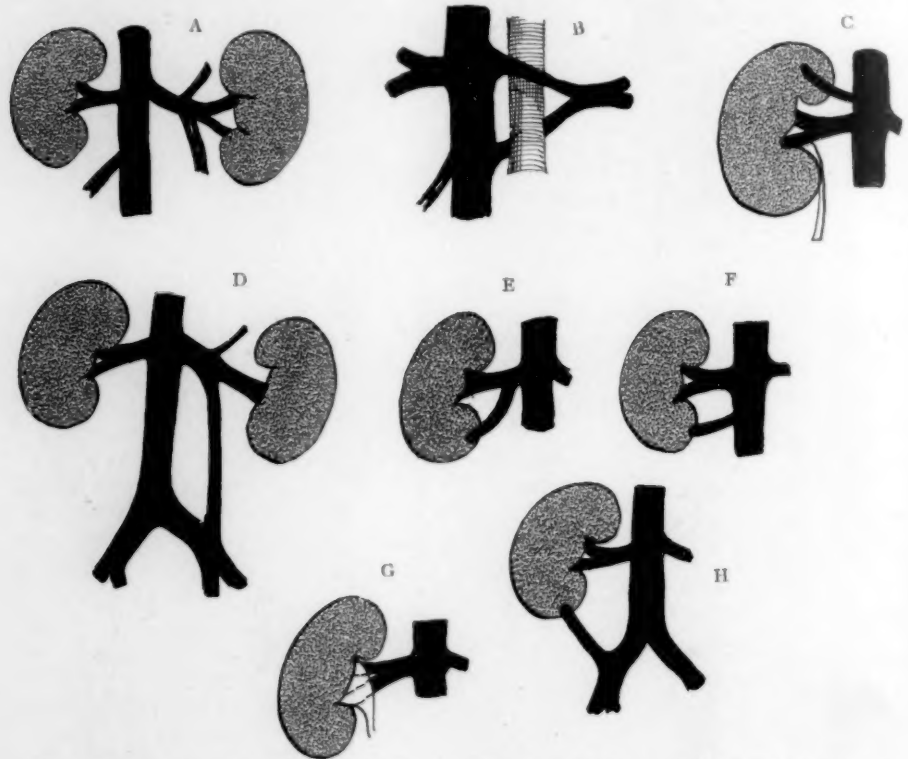


FIG. 20.—Anomalous (accessory) polar veins. A, Normal renal veins to each hilus. B, Double vena cava. C, Venous ring surrounding aorta. D, Superior polar vein from vena cava. E, Inferior polar vein from main renal vein. F, Inferior polar vein from vena cava. G, Inferior polar vein from common iliac vein. H, Main renal veins pass behind instead of in front of pelvis.

series of dilatations separated by narrowings. These are from above downward the following:

- (a) The ureteropelvic funnel or junction (B of Fig. 22).
- (b) The narrowing just below the preceding.
- (c) The lumbar dilatation or "spindle."
- (d) The iliac narrowing (where ureter crosses iliac vessels).
- (e) The pelvic dilatation or "spindle."
- (f) The juxtavesical narrowing which passes imperceptibly into
- (g) The intramural segment and ureteral orifice.

There may be considerable variation, *i.e.*, a certain number of narrowings or of spindles may be absent so that the lumbar and pelvic "spindles" are continuous (A of Fig. 22).

The true anomalies are:

# RENAL AND URETERAL ANOMALIES

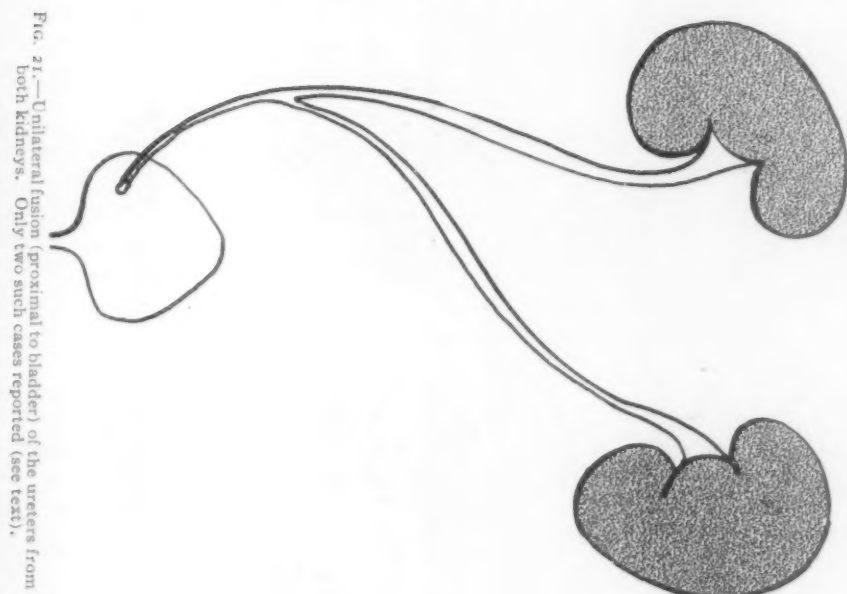


FIG. 21.—Unilateral fusion (proximal to bladder) of the ureters from both kidneys. Only two such cases reported (see text).

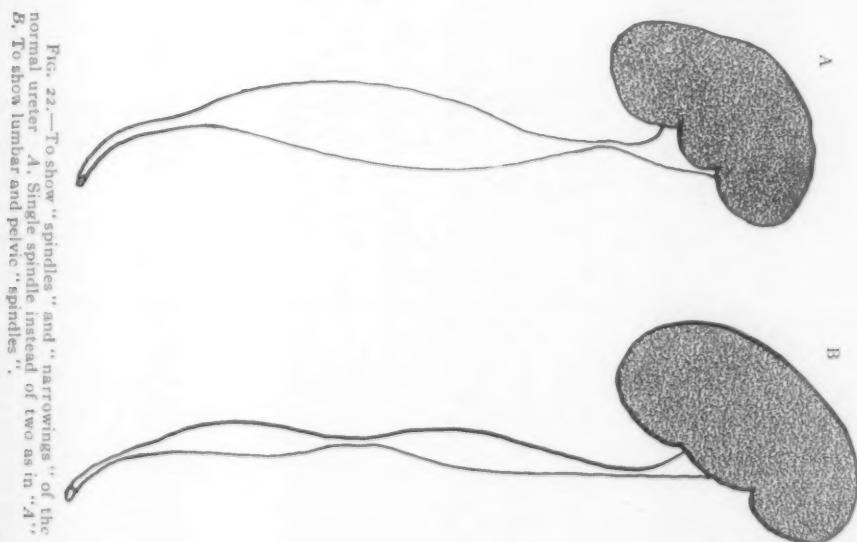


FIG. 22.—To show "spindles" and "narrowings" of the normal ureter. A. Single spindle instead of two as in "A". B. To show lumbar and pelvic "spindles".



A. *Congenital Strictures*.—These usually occur at the points of narrowing (A of Fig. 22), but can be found anywhere in the lumen of the ureter.

B. *Congenital Dilatations* (Fig. 23).—These can be (a) total (C of Fig. 23), including the entire ureter and its vesical orifice; (b) subtotal (B of Fig. 23)—all of the ureter except its vesical orifice and (c) partial, *i.e.*, forming a series of spindles as in A of Fig. 23.

The dilatation may be of such a degree that the ureter resembles a coil of intestine.

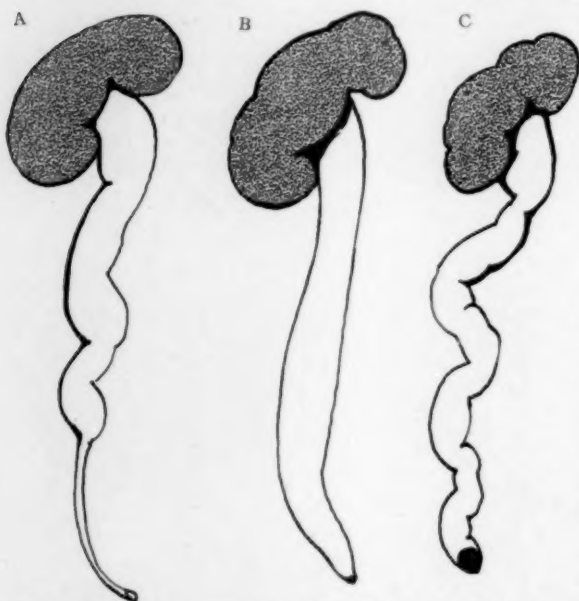


FIG. 23.—To show congenital ureteral dilatation. A, Partial dilatation. B, Subtotal dilatation. C, Total (complete) dilatation.

often as the result of either abnormal mobility of the kidney or redundancy, *i.e.*, excessive length of the ureter.

C. *Valves* (Fig. 24).—

These are found at both ends of the ureter, *i.e.*, near the renal pelvis or the vesical outlet. They are most commonly seen in the foetus or in the new-born.

D. *Spiral Twists and Kinks*.—The former involve the entire lumen, the tube appearing to be twisted upon itself (Fig. 25). Kinks usually are found in connection with faulty modes of origin of the ureter from the renal pelvis. They may, however, be found at any level,

### B. 3. ANOMALIES OF ORIGIN AND ENDINGS

(a) *Anomalies of Origin*.—In this group the ureter instead of arising from the funnel-like ending of the renal pelvis (A of Fig. 22) begins at a higher point so that as the pelvis fills, it compresses the ureter and gradually more and more of a pouch forms below the ureteral outlet. Rarely, as in Manasse's case, the ureter passes entirely around the top of the pelvis before proceeding toward the bladder.

(b) *Ureterocoele* (cystic dilatation of lower end of ureter).—Under this heading is included a dilatation of that portion of the ureter just proximal to the ureteral (vesical) orifice. It is usually the result of a narrowing less often a complete closure of the vesical orifice. Although in its early stages it presents (A of Fig. 26) as a cherry-sized swelling, it may attain an enormous size (B of Fig. 26) and occlude the opening of the opposite ureter or become incarcerated in the urethra (C of Fig. 26) or prolapse through the

# RENAL AND URETERAL ANOMALIES



FIG. 24.—Location of ureteral valves.

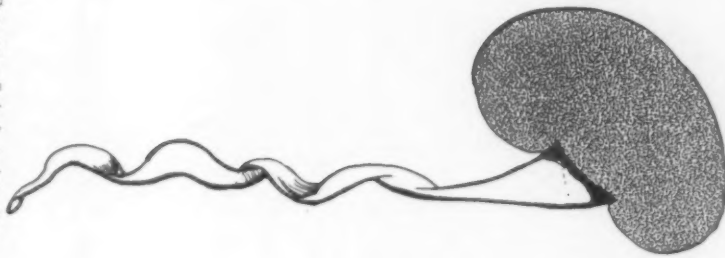


FIG. 25.—Spiral twist (top) of the ureter.



FIG. 26.—Various forms of ureteroceles (cystic dilatation). A, Small ampullary. B, Saccular (large). C, Prolapse through urethra (usually female). D, Prolapse through urethra (complete).

external meatus and present externally (D of Fig. 26). Such a prolapse usually occurs in the female.

(c) *Blind Ending Ureters*.—These present in two forms, usually as an

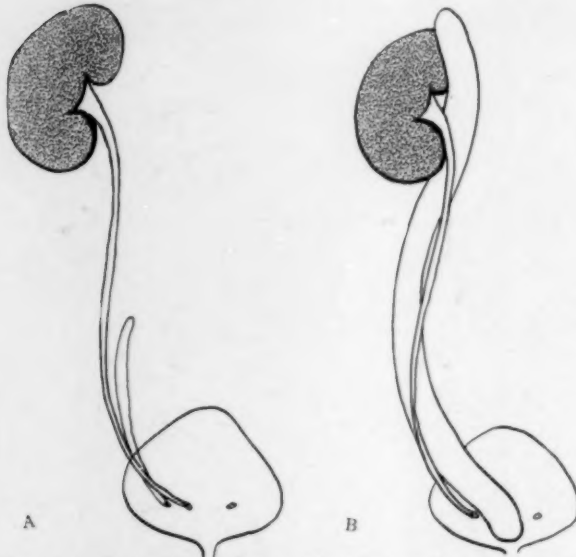


FIG. 27.—Blind ending ureters. A, Blind ending rudimentary ureter. B, Completely developed blind ending ureter.

accompaniment of reduplication of the ureters. In one form (A of Fig. 27) the second ureter is rudimentary and ends blindly above only. In the other form (B of Fig. 27) the second ureter ends blindly above and below. At times there is a hypoplastic half of a double kidney developed around a second ureter which ends blindly below.

(d) *Abnormal Ectopic Endings of the Ureters* (Fig. 28).—Although this

may occur in the case of a kidney having but one ureter, it is usually found in double kidneys, *i.e.*, reduplication of the ureters and renal pelves. One of the two ureters (usually the one ending more dis-

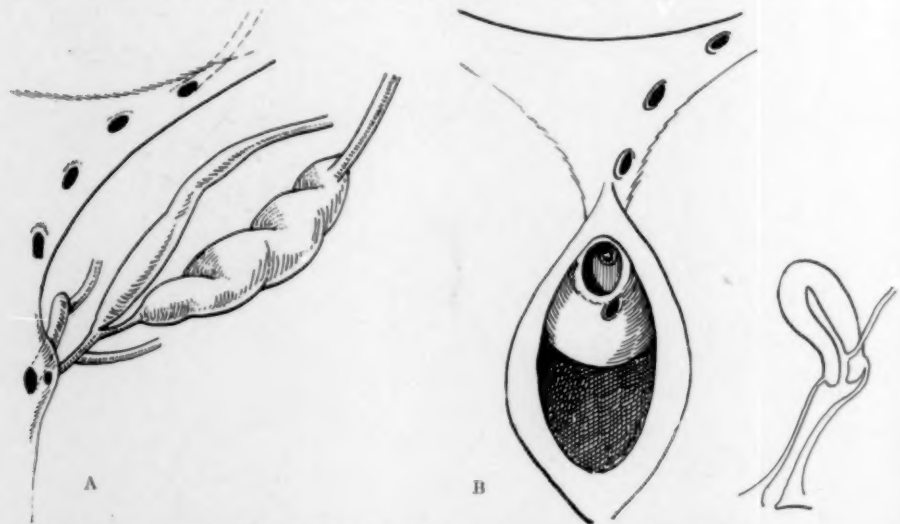


FIG. 28.—A, Abnormal (ectopic) ureteral endings in the male. From above downward note the possible endings in the bladder, prostatic urethra, utricule, ejaculatory duct and seminal vesicle. B, Abnormal (ectopic) ureteral endings in the female. Note possible endings in the bladder, urethra, at the meatus (external), vagina and uterus (seen in sagittal section).

tally) opens either at some point considerably below the opening of the ureter from the other half or it opens extravasically. The anomaly can be uni- or

# RENAL AND URETERAL ANOMALIES

FIG. 29.—Various types of single diverticula of ureter. A. Simple diverticulum. B. Ampullary diverticulum. C. Diverticulum ending in fibrous prolongation.

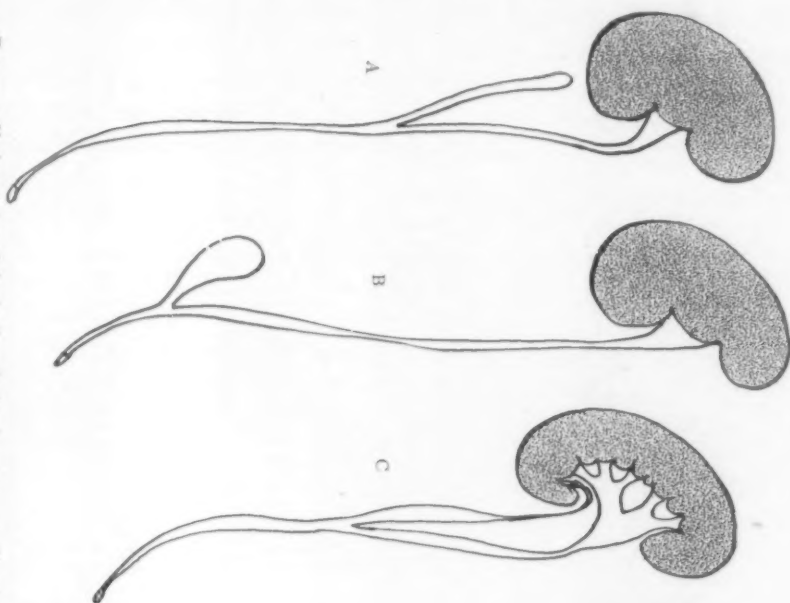
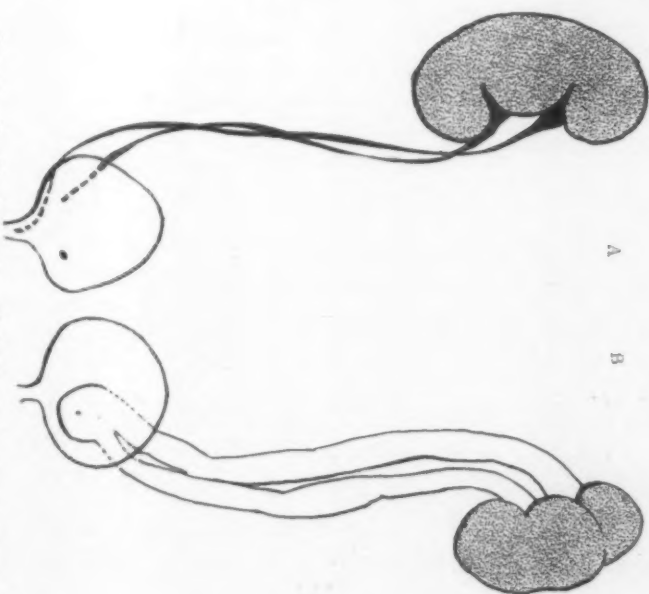


FIG. 30.—Multiple diverticula (Peper's case).



FIG. 31.—Combination of "double" kidney and ectopic ureteral ending. A. Complete reduplication of ureters and pelvis. One ureter (from lower half) ends at normal place but the other (from upper half) ends in urethra. A frequent finding in urinary incontinence due to ectopic ureteral ending. B. Both ureters of a "double" kidney end in a cystic dilatation.



bilateral both in the case of the ureter of a normal (single pelvis) kidney as well as in that of a reduplication of the pelves and ureters.

In the intravesical cases of abnormal ending the latter can be found anywhere between the location of the normal orifice and the internal meatus (Fig. 28). The location of the extravesical openings vary according to the sex of the individual. In males it can be located in the prostatic urethra up to the verumontanum, in the prostatic utricle, ejaculatory duct or seminal vesicle (A of Fig. 28). In females, the ureter can open in any portion of

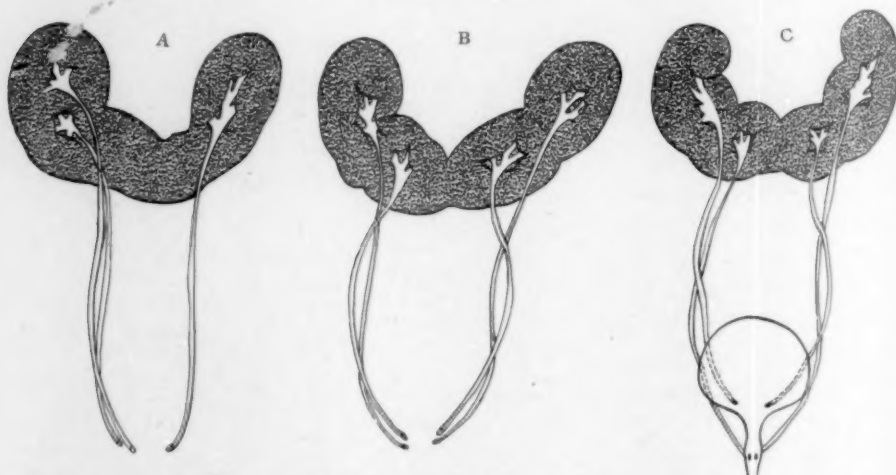


FIG. 32.—Combination of horseshoe and "double" kidney. A, Complete reduplication of renal pelves and ureters on one side only. B, Same on both sides. C, Same as B but one ureter on each side ends ectopically (in urethra).

the urethra, at the external meatus, vulva, anterior vaginal wall or neck of the uterus (B of Fig. 28).

(e) *Diverticula of the Ureter*.—One can find reports of cases of simple diverticula with blind upper end (A of Fig. 29) of ampulla-like diverticula (B of Fig. 29) or a termination in a long fibrous cord (C of Fig. 29) and finally as in Pepere's case of multiple diverticula (Fig. 30).

#### C. COMBINED ANOMALIES

Almost any combination of the principal types of both renal and ureteral anomalies may occur. We will only attempt to name the more common ones:

C. 1. *Congenital Solitary Kidney*.—(a) The presence of a solitary kidney in the normal renal location and of a rudimentary ureter on the opposite side (B of Fig. 1).

(b) The association of solitary kidney with ectopia (D of Fig. 2).

(c) The presence of the solitary kidney (crossed ectopia) on the side of the body opposite to that on which its ureter ends (B of Fig. 2).

C. 2. *Hypoplasia*.—(a) The association of hypoplasia of one kidney with a double kidney on the opposite side.



## RENAL AND URETERAL ANOMALIES

(b) The abnormal ending of the ureter of a hypoplastic kidney, *i.e.*, either blindly or in the urethra, seminal vesicle (Fig. 28), etc.

(c) Hypoplasia of one-half of a horseshoe kidney.

C. 3. *Horseshoe Kidney*.—(a) The presence of reduplication of the ureters and renal pelves in one or both halves of the horseshoe kidney (Fig. 32).

(b) Ectopia (simple) cake (one of varieties of horseshoe kidney) kidney (D of Fig. 10).

(c) Combination of ectopic ending of the ureter of one-half of a horseshoe kidney.

(d) Association of hypoplasia and horseshoe kidney.

C. 4. *Double Kidney*.—(a) Association of double and horseshoe kidney (Fig. 32).

(b) Ectopic ending of ureter of one-half of double kidney on one or both sides (A of Fig. 31).

(c) Blind ending or termination in a ureterocele of one or both ureters of a double kidney on one or both sides (B of Fig. 31).

(d) Hypoplasia of one-half of a double kidney on one or both sides.

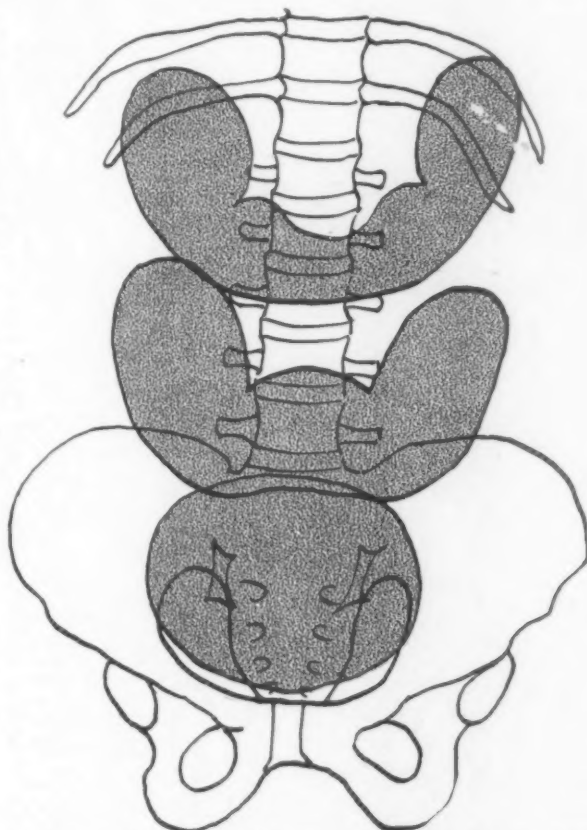


FIG. 33.—Combination of horseshoe kidney and ectopia. Note from above downward low lumbar, iliac and pelvic ectopia of the horseshoe kidney. The first two are the usual levels at which horseshoe kidneys are found. The pelvic type is always of the "cake" variety.

C. 5. *Combination of ectopia (ordinary) and horseshoe kidney* (Fig. 33).

### D. CONCOMITANT ANOMALIES (FIG. 34)

We will simply enumerate without taking up in detail the three principal groups of concomitant deformities, namely, (a) of the urinary tract in both sexes; (b) of the genital tract in the male; (c) of the genital tract in female.

(a) Concomitant urinary defects:

Exstrophy of the bladder.

Congenital dilatation of the bladder.

Diverticula of the bladder.

Congenital strictures or valve formations of the posterior urethra.

(b) Genital tract in the male (Fig. 34, B). Phimosis. Hypospadias. Non-descent of the testis.

Agenesis or lack of formation of the testis, prostate or seminal vesicles.

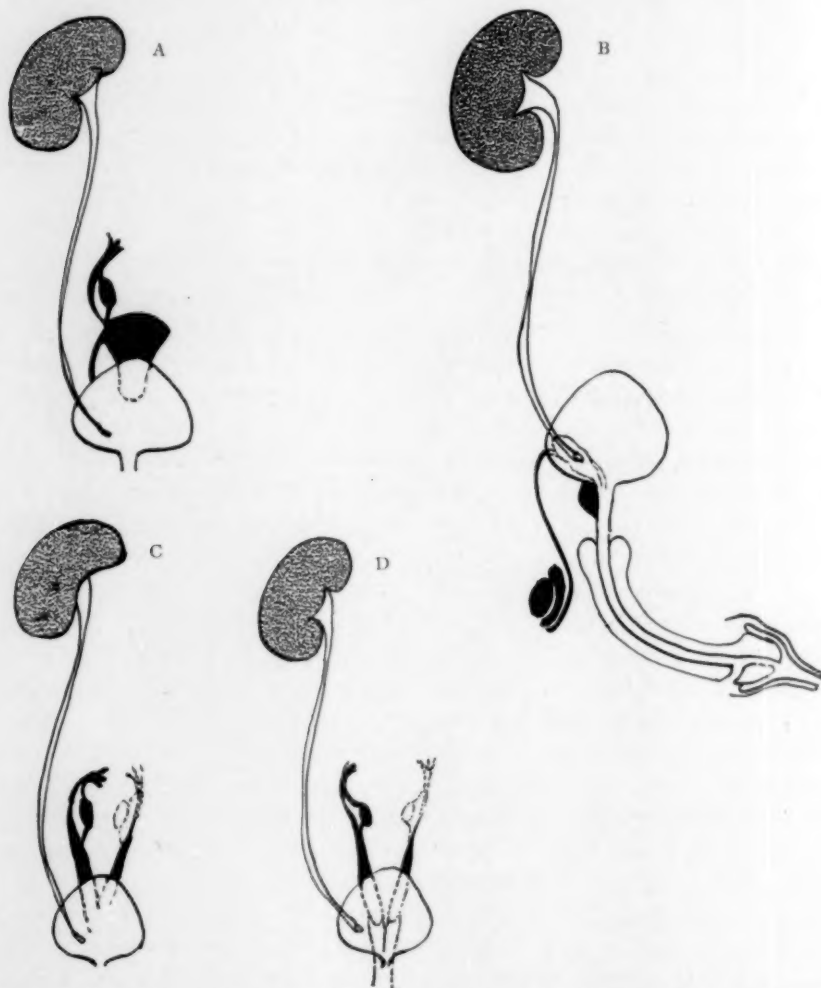


FIG. 34.—Various concomitant genital anomalies. In the female: A. Absence of ovary and tube on opposite side in congenital solitary kidney. B. Reduplication of uterus and vagina (with or without absence of a tube or of the ovary). C. Uterus bicornis (with or without absence of a tube or of the ovary). In the male: Most common anomalies are phimosis, hypospadias, absence of a seminal vesicle, of lobe of prostate, of a testis or of entire genital apparatus of one side.

(c) In the female (Fig. 34, A, C, D): Double vagina. Double uterus. Bicornate uterus. Absence of the ovary on one side. Absence of the tube on one side. Absence of uterine cornu on one side. Infantile uterus.

We have attempted to classify all of the anomalies of the kidney and ureter in as simple a manner as possible without omitting any essential points. We offer it as a plan which will facilitate the writing of articles on this subject.

## SPINAL ANÆSTHESIA WITH ANHYDROUS COCAINE\*

OBSERVATIONS ON 557 ADDITIONAL CASES

BY J. RALSTON WELLS, M.D.

OF PHILADELPHIA, PA.

MY ORIGINAL report in *ANNALS OF SURGERY*, April, 1920, was based on observations of a series of twenty-six cases of spinal anæsthesia in which anhydrous cocaine only was used as the anæsthetic agent. In so small a number, conclusions, if drawn, were of little value and could only serve as a guide for further studies.

Laboratory experimentation and clinical experience in the past six years with five hundred and fifty-seven patients have resulted in refinements of technic and safeguards to the patients, as well as a feeling of security to the surgeon. All observations are from personal experience without conscious relation to findings or conclusions of other surgeons using spinal anæsthesia.

The technic used originally by Dr. Paul Delmas, University of Montpellier, France, has continued to form the basis of our procedure. The instrumentation is so simple that any surgeon can use this form of spinal anæsthesia without special apparatus. A Luer fitted spinal puncture needle of No. 17 gauge, three or three and one-half inches in length, a two-inch Luer needle No. 18 gauge, and a twenty-five c.c. all glass Luer syringe, constitute the entire equipment.

The posture of the patient for administration is of no moment. I prefer the sitting position when possible. Tincture of iodine, followed by alcohol or a 2 per cent. mercurochrome solution, is painted over an area from the second lumbar vertebra to the sacrum and from crest to crest of the ilium. The skin at a point below the spine of the fourth lumbar vertebra, Tuffier's Point, is infiltrated with local anæsthesia. A tenotome puncture directly in the midline relieves the spinal needle of undue skin resistance. The needle is introduced directly in midline and at right angles to the skin surface. After the subarachnoid space is entered, the stilet is removed and the syringe is securely attached to the needle. The pressure of the spinal fluid often is enough to fill the syringe but if not, slow and gentle traction may be applied to the plunger. When twenty-five c.c. of the fluid is withdrawn, the syringe is disconnected and the stilet reinserted, allowing the needle to remain *in situ*. The two-inch No. 18 gauge needle is attached to the filled syringe and a measured amount of the spinal fluid is injected into the amber glass ampule which contains the dry crystals of anhydrous cocaine. The amount of cocaine in the ampule has been accurately weighed and varies from gm. .045 to gm. .06. The quantity of spinal fluid put into the ampule is enough to make each c.c. equal to gm. .01 of the cocaine. The crystals dissolve instantly and the specific gravity of the spinal fluid is unaltered. The fluid remaining in the syringe is sent to the laboratory for routine examination, including a Wassermann and Colloidal Gold tests.

\* Read before the Philadelphia Academy of Surgery, January 3, 1927.

# J. RALSTON WELLS

The **duration** of the anæsthesia is determined by the **amount** of cocaine used, and will be found to vary but slightly from the accompanying table:

Gm. .01 .....	20 minutes
Gm. .015 .....	45 minutes
Gm. .02 .....	1 hr. 15 minutes
Gm. .025 .....	1 hr. 50 minutes
Gm. .03 .....	2 hrs. 30 minutes

The analgesia is of the same degree whether a small or large amount of cocaine is used, time only is altered by the amount.

The **determined amount** of the cocaine solution is sucked into the syringe, the small needle is detached, the stilet removed from the spinal needle and the syringe *securely* reattached. From fifteen to twenty-five c.c. *more* of the spinal fluid is drawn from the spinal canal into the syringe, using gentle traction on the plunger. The amount withdrawn the second time is determined by the **patient's reaction**, which consists of a progressive headache generally occipital. In the early part of the series, we allowed the headache to increase until the patient uttered an involuntary high-pitched cry, but this has been found to be unnecessary. At present, we determine the point where the headache starts and continue to withdraw the fluid slowly, stopping when we judge the headache has almost reached the maximum. The reintroduction of the spinal fluid causes an immediate and complete cessation of the head pain. The entire procedure takes about three minutes. The entire contents of the syringe are now thrown back into the spinal canal with **force enough** to give the desired **height level** of analgesia. The **height** of analgesia is determined by the **force** exerted in reintroducing the spinal fluid-cocaine mixture. For personal convenience I recognize four pressures. Force I—Gentle and slow pressure giving analgesia to the level of the symphysis pubes. Force II—Slight pressure, giving analgesia to region of the umbilicus. Force III—Considerable pressure with consequent rapidity of reintroduction, which gives an area corresponding to the second rib anterior and including the arm. Force IV—All the pressure that can be obtained which gives analgesia of the whole body, including the head. The needle is removed and puncture sealed with collodion. The patient is placed in the position required for operation and given an intramuscular injection of c.c. .25 of adrenalin chloride solution (1-1000). This last procedure is the main modification of the original technic, and is very important. (See Chart 2.)

Blood-pressure, pulse, and respiratory observations are made every three to five minutes for the first fifteen to twenty minutes, and every ten minutes thereafter for the duration of the operation. Pulse and respiration are relatively unaltered.

The theory for withdrawal of spinal fluid and the constancy of obtaining various levels of analgesia in all individuals, large or small, is illustrated by this laboratory experiment. We are dealing with the spinal canal exclusive of the cranium, and every spinal canal *varies* in its size and fluid content, but is *constant* in proportion to the size of each individual. We used a glass tube of a length and calibre proportionate

## SPINAL ANÆSTHESIA WITH ANHYDROUS COCAINE

to the human spinal canal, and attached a half inch of rubber tubing to one end. The apparatus was held upright, rubber tube end down, filled with water and both ends sealed. A spinal puncture needle was introduced into the lumen through the rubber tubing, and a syringe filled with a methylene blue solution was attached to the needle. The blue, upon injection, was seen to permeate only the lower two inches. If half the water was removed from the glass tube before the blue was introduced, the blue permeated much higher, but if from this remaining half, two-thirds was removed into the syringe and re-injected, the entire fluid content became dyed. We used three sizes and lengths of tubes with approximately the same result, showing size or capacity is eliminated as a factor. By removing the spinal fluid in each patient to a common level or nearly so, as shown by the reaction of increasing headache, we create two constant factors, a lack of "superimposed liquid," and a partial vacuum. The reintroduction of the liquid is propelled from behind, and is sucked in by a vacuum and, possibly due to normal irritability of living tissues, may be forced upward by ripples or successions of small contractions and expansions of the subarachnoid membrane itself. All three factors are augmented upon increase in force of the introduced liquid.

The cocaine that we are using at present has been prepared in the Laboratory of Pharmacodynamics of the University of Pennsylvania. The formula is that devised by Professor Gardin of the University of Montpellier, France. The finest cocaine obtainable is used. To one gramme of cocaine crystals in a glass flask, 25 c.c. of absolute alcohol is added, agitated, and allowed to stand three or four hours. Then while gently shaking the flask, 150 to 200 c.c. of dry ether is added. A crystalline deposit and precipitate are formed. This is allowed to stand from twenty to sixty minutes, the liquid is then syphoned off and the crystals dried in a sulphuric acid vacuum chamber. The crystals are removed in a sterile manner, weighed, and sealed in sterile amber glass ampules, care being taken not to allow the crystals to be long in contact with the air. A culture is taken from each ampule before sealing.

For experimental purposes, the syphoned liquid was evaporated and a substance obtained which resembled light brown sugar in color and texture. Several hundred ninety-gramme white rats were used and while the results were not conclusive, they were suggestive. I will not go into the minutiae of the experimentation but briefly state the gross results. We injected hypodermically: Control rats, Group I, with the commercial cocaine in varying amounts; Group II, with anhydrous cocaine, and Group III, with the residue from the decanted liquid dissolved in normal saline solution. The rats in the second group were less affected than those in the first group for like amounts of cocaine, while those in the third group showed a marked susceptibility over either Groups I or II for like amounts by weight. The residue is apparently three or more times as toxic as the cocaine used in Group I. We have never been able to identify the residue from a chemical standpoint, which is unlike the original cocaine in color, crystalline formation and toxicity. We coined the term "Anhydrous Cocaine" to differentiate this product from all



others. It loses its cocaine crystalline formation and takes on the appearance of a flake, is hygroscopic and instantly soluble in water or spinal fluid. A new drug has not been created, but C. P. cocaine has been further purified, thus reducing its toxicity, making the cocaine thus obtained less toxic. The action of the cocaine is apparently unaltered in so far as analgesia is concerned. There is a large field of experimental work to be done before these facts can be established. Our work is to be taken as indicative only. I think with all fairness I may state that we have never had a death due to anhydrous cocaine spinal analgesia, *per se*. This in comparison with other reports, numerically equal on intraspinal cocaine use, shows a lessened toxicity. The future may reveal in the hands more able than ours, that this cocaine is less toxic for all general uses that cocaine may be put to. I would like to suggest that the term "Anhydrous Cocaine" be retained.

Several facts are peculiar to this anæsthetic. (1) The entire body, including the head, can be and has been safely rendered insensible to pain. (2) The height level of analgesia can be accurately determined within two inches. (3) The duration of the analgesia can be prognosticated within five to ten minutes. (4) The area of analgesia, once established, is unalterable, regardless of the position of the patient, whether prone, Fowler's, or Trendelenburg, and these positions may be changed during the operation without alteration of analgesic level. (5) Analgesia is immediate.

As cocaine in safe doses affects only sensory nerves, therefore, when introduced into the spinal canal shows a preference for the posterior roots, leaving the anterior roots unaffected. Anhydrous cocaine retains this quality, and permits analgesia of the entire body, yet leaves the motor and vital functions undisturbed. Herein it differs from all other local anæsthetics, stovaine, novocaine and apothesine included, in that each of them paralyzes both motor and sensory nerves.

The immediate analgesic action and its unvarying level once established, regardless of the patient's position, remain unexplained.

Cocaine deteriorates more or less rapidly in white or blue glass. The preparation we are using was made and sealed in amber glass ampules three years ago, and is as potent as when first prepared.

In addition to our five hundred and fifty-seven cases under anhydrous cocaine, we gave three novocaine, two stovaine-alcohol-acetic acid (Babcock), and one apothesine spinal anæsthesias. We have had one death under anhydrous cocaine in a very toxic patient with a severe myocarditis and almost moribund. Any operative procedure was of extreme danger regardless of anæsthetic used. There were nine failures of analgesia. Three of these were ascribed to inert cocaine due to the accidental heating of the ampules, and one, to failure to completely entering the spinal canal. In twenty-two cases, there was either poor analgesia or the effect wore off before the expected time, and in seven, a general anæsthetic was given on account of extreme nervousness of the patient. A failure of a little over  $6\frac{1}{2}$  per cent.

By far the greatest proportion of operations were below the level of the umbilicus. There were seven gall-bladders, three rib resections, one major

## SPINAL ANÆSTHESIA WITH ANHYDROUS COCAINE

thoracoplasty (removing a section of the second to ninth ribs inclusive), one compound fracture of the inferior maxilla, one lipoma of scalp, and two trephines.

With the exception of thirty-two cases, all have been those that, in the opinion of the operating surgeon, were unfit for any other form of anæsthesia. They constitute the "last hopes" where surgical intervention is considered necessary to save life or to alleviate a lingering, painful existence. They include chronic alcoholics, drug addicts, all types of arteriosclerotics, the extremely obese, all grades of the intoxications including the diabetic, advanced cardiac and pulmonary conditions. Herein is a point of difference between this and most other spinal anæsthesia reports, and strengthens our opinion that we are using a less toxic drug than C. P. cocaine.

Two hundred and eighty-six cases (50 per cent.) were nauseated or vomited within the first five minutes after spinal injection. Nausea terminated within eight minutes from time of onset in all but five cases, one of whom was nauseated for two days. The nausea in these five may have been due to the anæsthetic or technic, but more likely to the pre-operative morphine. The inhalation of aromatic spirits of ammonia lessens the severity and length of the nausea and incidentally may raise the blood-pressure.

Blood-pressure has been our greatest problem. In common with all other

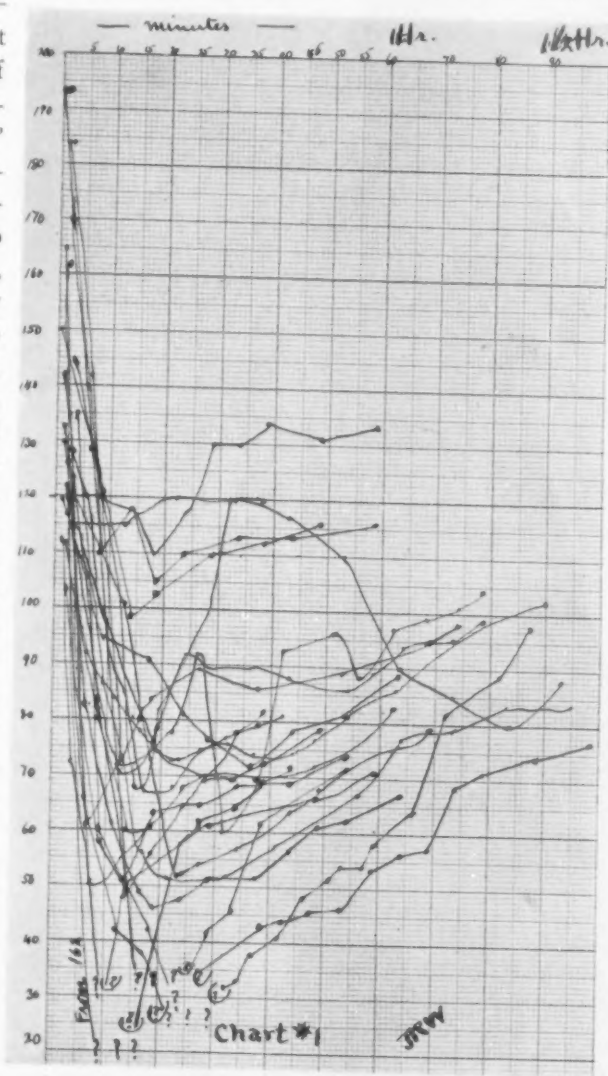


CHART I.—Composite of twenty average curves taken from the first 150 cases. This gives the idea of the abrupt fall in systolic blood-pressure. Diastolic blood-pressure follows the systolic but not so marked, the pulse pressure is therefore less. A larger number of cases are not charted on account of confusion of lines of curve. Diastolic pressures not charted for the same reason.

spinal anæsthetics of which I have any knowledge, anhydrous cocaine has a sudden, profound, depressing effect on the diastolic and especially the systolic pressure. A low blood-pressure constitutes the only other contra-indication to spinal anæsthesia, aside from spinal syphilis, tumors of the brain or cord, and

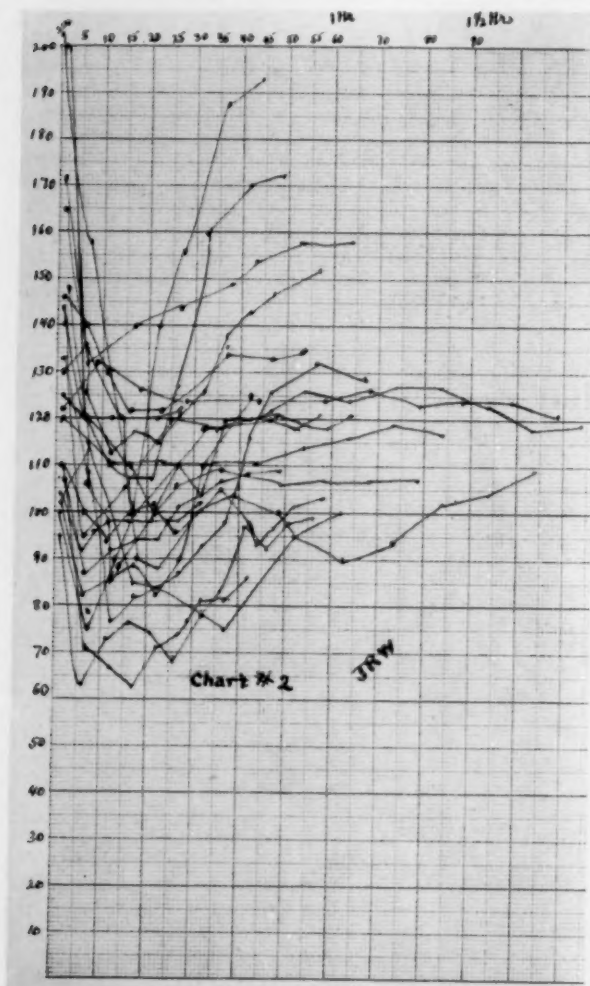


CHART 2.—Composite of twenty average curves after the first 300 cases. Note the change in the general low limits due to the routine administration of adrenalin chloride solution 1-1,000, intermuscular hypodermic. Several have had two injections of c.c. 0.25.

to give a moderate dose of adrenalin to every patient *immediately* following the spinal injection. If dose is administered deep in deltoid muscle, it will give positive results within sixty seconds. We have found a quarter of one c.c. to be sufficient in the majority of cases. Of two hundred and fifty-one thus routinely injected, sixty-four have needed one or two additional doses of same size. Ordinarily a patient should not be allowed a systolic pressure below seventy or diastolic below forty. Adrenalin chloride has not failed in emergency.

Two composite charts have been made (Chart 1 and Chart 2), one before

local suppurative processes in the immediate neighborhood of the spinal puncture. In the beginning of our series, very little, if anything, was done to raise the blood-pressure when it became very low. (Chart 1.) Since then several drugs have been used alone and in combination, both before and after injection of the spinal canal. Doctor Delmas has suggested an elaborate mixture consisting of caffeine, spartein, sodii benzoate, and strychnine. We used this in sixteen cases. Pituitrin and ergot together were used in forty-four cases, ergot alone in twelve cases, and strychnine sulphate in six cases.

For the past two years adrenalin chloride 1-1000 solution has been used when a low blood-pressure was registered. Since lowered blood-pressure is an almost constant factor, it has become routine

## SPINAL ANÆSTHESIA WITH ANHYDROUS COCAINE

and one after the establishment of the routine administration of the adrenalin chloride. The first one shows pressures registered all the way down the scale, several falling below the audible stage. In one of these for seven minutes I could not feel a radial or carotid pulse, and could only hear a precordial beat. The first audible sound with a sphygmometer was at 33. There was no differentiation between systolic or diastolic. The patient made an uneventful recovery. With the low pressures shown in the first chart consciousness very often lapsed for from one to fifteen minutes. With the second chart, we have *no* very low pressures and no lapses of consciousness. With too large a dose of adrenalin, however, we have had some dangerously *high* pressures. A quarter of a c.c. gives a decided reaction which lasts for fifteen to twenty minutes and if necessary, this dose may be repeated.

Normal pressures are reestablished in one to six hours, some requiring as long as eighteen hours. In one case a very toxic seventy-one year old man, with moist gangrene of a foot, having a pressure of 90 over 44, showed a rise of pressure to 120 over 70. We were not using routine adrenalin chloride at that time. He made a satisfactory recovery and left the hospital with the increased blood-pressure maintained. Two other cases have had rises of blood-pressure without adrenalin chloride, but neither one as well sustained.

The diastolic pressure is the most important, but owing to the systolic pressure being the most sensitive and the diastolic being usually in relative proportion, the systolic is here used to indicate recorded blood-pressure. By diastolic pressure is meant the absolute cessation of all sounds after the systolic high has been noted. In the occasional case the sounds continue to zero, but these are excepted. A patient with a systolic of 120 and a diastolic of 50 is a far greater risk than one of 100 over 60 or one of 160 over 110. One with a low diastolic shows a lack of resistance. A reasonable chart can be built on this theory of normal resistance with certain prognostic signs clearly indicated. With a pre-operative pressure of 140 over 90, a reasonable reading during the first five minutes would be 70 over 50, gradually rising to within ten points of normal in the next hour. If the curve is lower, for example, 55 over 30, and then the gradually rising pressure, we are uneasy until the rise is definite and our patient has been in danger of cerebral anæmia and the other results of acute hypotension. The administration of adrenalin chloride or any other drug will not alter the normal *resistance* curve as such (Chart 3), but will give a transient or false *pressure* rise and thus temporarily overcome the dangers of low blood-pressure. If the normal resistance has not recovered sufficiently when the adrenalin effect is spent, a falling pressure recurs, and a second adrenalin dose is given. If the normal resistance has now recovered sufficiently to keep the pressure in safe levels, when the adrenalin effect is over, we do not need further drug action. The normal resistance is vital and should be given major attention in spinal anæsthesia. The low resistance curve can be prognosticated when the diastolic is abnormally lower than the systolic, or when the first several blood-pressure readings after the administration of spinal anæsthesia show a fall in diastolic as rapid or profound as in



the systolic. Overstimulation with adrenalin chloride is a very real danger. One case in this series rose from 63 to 180 systolic in ten minutes after the injection of one c.c.

The after effects of dizziness, headache, formication, "weak back," and many other recorded symptoms, are almost absent in this series. We have had fourteen cases of headache, one lasting three days. One case of unusual interest had a drooping of the left upper eyelid lasting for over two weeks and one case of blindness of the left eye for five days. Neither was perma-

nent in the slightest degree. Similar findings have been recorded following spinal puncture alone.

Spinal pressure readings have not been made routinely, but if taken would undoubtedly be of interest when contrasted with the blood-pressure curve during the analgesic stage.

Pre-operative preparation is of importance, as in any local anaesthesia. At present we are using the three injections as advised by Gwathmey at

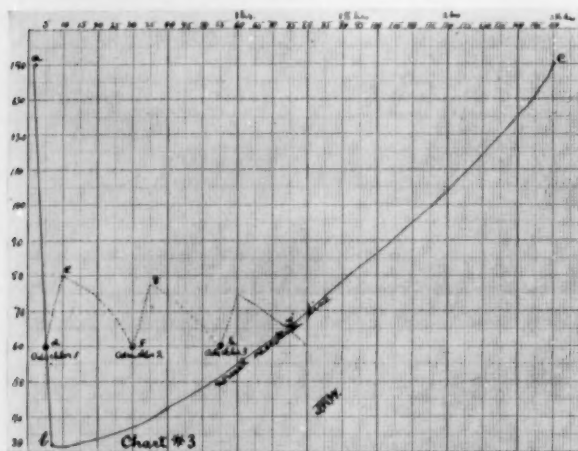


CHART 3.—This is at present, theoretical. We call the curve a-b-c the normal resistance line. It represents the systolic pressure if left unaltered by drugs and therefore the reaction of the cardio-vascular-motor system, line d-e-f-g-h-i-j, adrenalin chloride alters the pressure symptomatically and transiently, but does not alter basic blood pressure. At point j the adrenalin line crosses the normal resistance line, and the necessity for further drug administration ceases.

half-hour intervals, each consisting of morphine sulphate gr.  $\frac{1}{8}$ , 2 c.c. of 50 per cent. solution of magnesium sulphate. This is injected intermuscularly. For a 9 A.M. operation, give doses at 7.30, 8 and 8.30 A.M. We add atropine sulphate, gr.  $\frac{1}{100}$ , to the second injection. In the past both large and divided doses of morphine and atropine with and without scopolamin, were used, but the present technic has proved the most satisfactory.

The rapid perfection and safety of other forms of local anaesthesia will cause them to supplant the spinal procedure in a large measure, but in certain cases, spinal anaesthesia will be the one of choice. Whether anhydrous cocaine is less toxic than that obtained commercially, is yet to be adequately proven, but in our hands it has been safe, reliable, and easily controlled.

I wish to express my appreciation for the facilities and aid, both material and advisory, extended by the Department of Pharmacodynamics of the University of Pennsylvania, the Department of Health of the City of Philadelphia, and by the Hospital and Laboratory of the Philadelphia General Hospital.



# THE USE OF REGIONAL ANÆSTHESIA BY THE NERVE BLOCK METHOD FOR THE REDUCTION OF FRACTURES AND DISLOCATIONS

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THE successful employment of regional anæsthesia in other forms of extremity surgery was the stimulus for determining its value in the reduction of fractures and dislocations. In any active surgical clinic, cases frequently occur necessitating its use. The ordinary well-known contra-indications to inhalation narcosis in general surgery are applicable in the same degree to this particular problem, and frequently cause us to abandon or modify the treatment that would be attempted on a younger or more hardy individual. How often, because of the question of anæsthesia, is a Colles' fracture in an elderly individual allowed to go unmodified, when a similar fracture in a younger patient would demand immediate correction? Not infrequently because of some specific anæsthetic contra-indication, in order to avoid ether or chloroform, we attempt a gas and oxygen reduction of a fracture, with a resultant unsatisfactory relaxation, causing either a difficult reduction or a final reluctant resorting to the anæsthetic agents we wished to avoid. Simple and compound fractures complicated by injuries elsewhere, acute respiratory infections, or threatening shock, are often treated expectantly, thereby rendering later reduction difficult and militating against a good result. There are appreciable minor objections encountered in fracture work which are more or less dependent on general anæsthesia. A certain amount of apprehension must be experienced by the surgeon and anæsthetist while working in the dark fluoroscopic room, and manipulations are occasionally hurried, interrupted, and hampered while checking up on a patient's condition. An unexpected anæsthetic recovery is always a potential source of ruining a perfect reduction. With the impression that regional anæsthesia might overcome some of these objectionable features, a series of fractures and dislocations were reduced by this method with the object of evaluating its relative merit, and of determining its actual indications.

Local anæsthesia, commonly implies anæsthetization accomplished by the actual infiltration of the anæsthetic fluid into any local part. Technically it must be differentiated from regional anæsthesia, which is the anæsthetization of a local region by depositing an anæsthetic drug about the nerve or nerves supplying it (nerve block); or by creating an encircling wall of anæsthesia (field block), about a given region by infiltrating the tissues in certain planes so as to block the supplying sensory nerves. Local infiltration anæsthesia in fracture work has been sporadically advocated since 1885, when Conway first reported the successful reduction of three cases of fracture of the radius by the use of cocaine. Reclus in 1903; Lerda in 1907; Quenu in 1908 and Cohen in 1926, reported successful results by similar methods. Dolinger and Hagen-

back advocated the circular infiltration of novocaine proximal to the site of fracture causing a conductive anaesthesia, a procedure involving the same technical objections which pertain to the infiltration method. Except for Braun's report in 1913, of the successful reduction of twenty upper extremity fractures and dislocations, by the brachial plexus block in a general series of fifty cases reduced by "local methods," no mention was found in the literature of a series of cases treated by the method under consideration.

Our study was confined specifically to regional anaesthesia by nerve block, as this seemed to be the desirable and logical method to be used in the presence of the pathology associated with fractures and dislocations. The actual infiltration of an anaesthetic fluid into or about the traumatized tissues involved in any osseous or joint injury seems to us an unsurgical and objectionable procedure, as it means further traumatization to already injured tissues and adds potential factors to delay healing and increase the possibilities of infection. It is obviously contra-indicated in the case of the compound fracture, as well as the simple fracture with severe injury to the soft parts. In principle, the infiltration method is the conversion of the simple fracture into a compound fracture, and although some of the advocates of this method are willing to relegate these objections to a theoretical level, because of confidence in aseptic methods and failure of infection in a very limited series of cases, we feel the method is unsurgical, and should rarely be attempted.

Nerve block produces an anaesthesia of an involved area and avoids damage to the already injured tissues. In principle, its use depends upon the physiological section of a nerve at any level by depositing an anaesthetic fluid in or in close proximity to it with a resultant anaesthesia of the region it supplies. Anatomical levels favor us with sites of variable selectibility to block the nerves to anaesthetize any local area. The injection of a given solution close to the spine and at the emergence of the nerve trunks is called "paravertebral block." Injection through the posterior foramina of the sacrum to anaesthetize the sacral nerves is termed "transacral block." The types of lesions, with which we are concerned, are essentially those of the upper and lower extremities. Thus a physiological section of the brachial plexus at the proper site with the proper technic will anaesthetize the whole upper extremity; similarly the block of the individual nerves—median-ulnar-radial—at the elbow will anaesthetize the forearm and hand; a block of the sciatic or the popliteal nerves in the popliteal space, the leg and foot; or in principle the deposition of the drug about any nerve will temporarily anaesthetize the area it controls.

To estimate the actual value of nerve block anaesthesia as a procedure for use in fracture work, an attempt was made to determine its efficiency in fulfilling the various requisites of a satisfactory anaesthetic. Any anaesthetic used in the reduction of fractures and dislocations may be said to have two prime requisites. The first, is to render the procedure painless, and the second is to establish adequate muscle relaxation to allow the restoration of fragments to desirable positions.

The choice of the type of case was governed by the therapeutic indications

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more or less standardized for this clinic. The main criterion was that the type of fracture or dislocation be one that should warrant an immediate manipulative reduction under an anæsthetic, in contra-distinction to the one indicating prolonged traction and suspension. The adaptable cases are essentially those of the extremities and our series includes one or more of each type (Table I). In the upper extremity, all fractures and dislocations are suitable; but in this clinic, those of the neck and shaft of the humerus are commonly treated by traction and suspension. In the lower extremity, the fractures of the femur are not available to nerve block because of anatomical inaccessibility, and moreover, because they are treated almost without exception, by traction and suspension. The lesions of the leg and foot are however, available to regional nerve block methods.

TABLE I  
*Types Treated*

Upper extremity	Number of cases
Dislocation of shoulder .....	3
Dislocation of elbow .....	2
Fracture of humerus .....	2
Fracture of shaft of radius and ulnar .....	3
Fracture of shaft of radius .....	1
Fracture of lower extremity of radius (Colles) .....	12
Dislocation of first metacarpal .....	2
Fracture of metacarpal .....	3
Fracture of phalanges .....	5
Dislocation of phalanges .....	3
Fracture of shaft of tibia and fibula .....	1
Fractures of lower extremity of tibia or fibula (Potts) .....	5
Fracture of external malleoli .....	2
Fracture of os calsis .....	2
Fracture of metatarsal .....	2
Fracture of phalanges .....	2

As far as our first factor is concerned, the method has been almost uniformly satisfactory. (See Table II.) The state of analgesia if the technic has been properly carried out, is readily acquired and usually lasts one to two hours. At times, however, other afferent sensibilities, *e.g.*, pressure, position, and vibratory sensation, are apparently not obliterated, but greatly diminished so as to give the patient a conscious sensibility which may be slightly disagreeable, but not painful. Unless proper coöperation is obtained, these may be misinterpreted. During the actual manipulations, they naturally may become more pronounced, but at no time do they become of such moment as to be a potential source of shock. The patient may moan or complain, and then later admit he had no pain. These afferent sensibilities may be variable and most frequently are obliterated; but to guard against their presence being a factor for failure, it is necessary to allay mental apprehension and obtain the coöperation of the patient. These precautions are necessary to insure the success of any "local" operation, and the preliminary use of morphine when

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TABLE II.

Number	Diagnosis	Procedure	Analgesia	Relaxation	Result
4275	Fracture of lower extremity radius—"Colles"	Elbow	Complete	Adequate and satisfactory	Successful.
3148	Lower extremity of radius and ulnar—Styloid—Colles	Elbow	Complete	Adequate and satisfactory	Successful.
11045	Lower extremity of radius—Colles	Bracheal	Complete	Adequate and satisfactory	Successful.
8882	Lower extremity of radius—ulna—Styloid—Colles	Bracheal	Complete	Adequate and satisfactory	Successful.
4546	Lower extremity of radius—ulna—Styloid—Colles	Bracheal	Complete	Adequate and satisfactory	Successful.
4748	Lower extremity of radius and ulna—Styloid—Colles	Elbow	Conscious of pressure	Spasm and resistance of arm musculature	Successful.
6041	Colles—Lower extremity of radius	Bracheal	Complete	Adequate and satisfactory	Successful.
11275	Lower extremity of radius—Colles	Bracheal	Complete	Adequate and satisfactory	Successful.
11270	Colles—Lower extremity of radius	Elbow	Complete	Spasm and resistance of arm musculature	Successful.
6534	Colles—Lower extremity of radius	Elbow	Conscious of pressure	Spasm and resistance of arm musculature	
7233	Colles—Lower extremity of radius	Bracheal	Complete	Adequate and satisfactory	Successful.
6888	Colles—Lower extremity of radius	Bracheal	Complete	Adequate and satisfactory	Successful.
4349	Dislocation of shoulder—Subcoracoid	Bracheal	Complete	Adequate and satisfactory	Successful.
11976	Dislocation of shoulder—Subcoracoid	Bracheal	Complete	Adequate and satisfactory	Successful.
11552	Dislocation of shoulder—Subcoracoid	Bracheal	Complete	Adequate and satisfactory	Successful.
7236	Dislocation of elbow—Backward	Bracheal	Conscious of pressure	Adequate and satisfactory	Successful.
F. K.—Private	Dislocation of elbow—Backward	Bracheal	Complete	Adequate and satisfactory	Successful.

## REGIONAL ANÆSTHESIA IN FRACTURES

TABLE II—Continued.

Number	Diagnosis	Procedure	Analgesia	Relaxation	Result
4756	Fracture of shaft of humerus—Middle $\frac{1}{3}$ —Open operation	Bracheal	Conscious of pressure	Adequate and satisfactory	Successful.
13855	Fracture of lower extremity of humerus—External condyle	Bracheal	Complete	Adequate and satisfactory	Successful.
3381	Fracture of shaft of radius and ulna—Middle $\frac{1}{3}$	Elbow	Conscious of pressure	Spasm of arm muscle	Successful.
6757	Fracture of shaft of radius and ulna—Middle $\frac{1}{4}$	Bracheal	Complete	Adequate and satisfactory	Successful.
1791	Shaft of radius and ulna—Middle $\frac{1}{3}$	Elbow	Complete	Spasm of arm muscle	Successful.
6534	Dislocation of first metacarpal	Median and radial	Complete	Adequate and satisfactory	Successful.
3982	Dislocation of first metacarpal	Elbow	Complete	Adequate and satisfactory	Successful.
1817	Fracture of first metacarpal—Compound	Elbow—Radial and median	Complete	Adequate and satisfactory	Successful.
7371	Fracture of shaft—First metacarpal	Radial and median	Complete	Adequate and satisfactory	Successful.
8162	Fracture of shaft—Fifth metacarpal	Ulna	Complete	Adequate and satisfactory	Successful.
3651	Compound fracture of proximal phalanges—3, 4, 5-fingers	Elbow	Complete	Adequate and satisfactory	Successful.
5220	Compound fracture of phalanges—1, 2, 3, 4	Elbow	Complete	Adequate and satisfactory	Successful.
11314	Fracture of proximal phalanx—Index	Lateral nerves	Complete	Adequate and satisfactory	Successful.
11520	Fracture of proximal phalanx—Index	Lateral nerves	Complete	Adequate and satisfactory	Successful.
8176	Dislocation of proximal phalanx ring finger	Lateral nerve	Complete	Adequate and satisfactory	Successful.
6071	Dislocation of proximal phalanx 5th finger	Ulna	Complete	Adequate and satisfactory	Successful.
6074	Dislocation of second phalanx—Index finger	Lateral nerve	Complete	Adequate and satisfactory	Successful.



## SIGMUND MAGE

TABLE II—Continued.

Number	Diagnosis	Procedure	Analgesia	Relaxation	Result
5395	Compound fracture of phalanges—1, 2, 3, toes	Ankle	Complete	Adequate and satisfactory	Successful.
3950	Dislocation of proximal phalanx—Index	Median	Complete	Adequate and satisfactory	Successful.
7371	Fracture of lower extremity of tibia and fibula	Popliteal	Complete	Adequate and satisfactory	Successful.
4420	Fracture of shaft of fibula—lower $\frac{1}{3}$ —Lower extremity of tibia	Popliteal	Complete	Adequate and satisfactory	Successful.
4412	Fracture of shaft of fibula—Lower $\frac{1}{3}$ and lower extremity of tibia	Popliteal	Complete	Adequate and satisfactory	Successful.
4956	Fracture of shaft of fibula—Lower $\frac{1}{3}$ and lower extremity of tibia	Popliteal	Complete	Adequate and satisfactory	Successful.
5522	Fracture of lower extremity of fibula—Lateral malleolus	Popliteal	Complete	Adequate and satisfactory	Successful.
1355	Fracture of lower extremity of fibula—External malleolus	Popliteal	Complete	Adequate and satisfactory	Successful.
6897	Fracture of shaft of fibula—Lower $\frac{1}{3}$	Popliteal	Complete	Adequate and satisfactory	Successful.
4931	Fracture of os calcis	Ankle block, Anterior and posterior nerves	Complete	Spasm and resistance of Tendo-Achillis	Unsuccessful.
5634	Os calcis	Popliteal	Complete	Adequate and satisfactory	Successful.
6030	Fracture of first metatarsal	Ankle block	Complete	Adequate and satisfactory	Successful.
4640	Fracture of first metatarsal	Ankle block	Complete	Adequate and satisfactory	Successful.
4540	Compound fracture and dislocation of first phalanx—Large toe	Ankle	Complete	Adequate and satisfactory	Successful.
2183	Fracture of proximal phalanx—Middle	Median and ulna	Complete	Adequate and satisfactory	Successful.
6576	Compound fracture of shaft of tibia and fibula—Middle $\frac{1}{3}$	Popliteal	Conscious of pressure	Spasm and resistance of thigh muscles	Successful.

## REGIONAL ANÆSTHESIA IN FRACTURES

not contra-indicated, dulls sensibility sufficiently to acquire this end. As a routine part of every procedure, the patient is given  $\frac{1}{4}$  grain of morphine. This has been apparently sufficient to remove these features.

The second requirement of any satisfactory anæsthetic in fracture work is the capacity to supply adequate muscle relaxation. Malposition of fragments are most often dependent on the resultant of muscle forces, and muscle spasm is frequently the chief factor in preventing ready reductions. Judging from our experience with general narcosis, it would seem that complete muscle relaxation is essential, before manipulations can be attempted, as the lighter stages of anæsthesia tend to increase muscle spasm and render procedures more difficult. Experience with complete regional blocks for other surgical conditions revealed that chiefly the sensory elements are modified and the motor elements less so. As a rule, when the brachial plexus is blocked, there is the complete loss of pain sensibility, and usually a loss, or a diminution of pressure, position, and vibratory senses. Motor function is considerably modified but not obliterated. The patient can move his fingers, wrist, and forearm, but rarely can he lift his arm from a dependent position or offer any synergic resistance to opposing effort. The tonicity of the musculature is altered to a striking degree and a muscle paresis, but not a paralysis, prevails. The same general conditions are found with other regional blocks. The degree of this residual tonicity to all intent and purpose, seemed apparently negligible, but because of its practical importance in this particular problem, it was felt necessary to evaluate its actual and its potential limitations.

The most practical way to determine the adequacy of muscle relaxation after nerve block, seemed to be to try the method on cases presenting the most unfavorable mechanical factors without considering the question of specific anæsthetic indications. Although an attempt was made to select the cases with this point in mind, the criterion for the type of fracture or dislocation to be tried was, as previously mentioned, the one established at this clinic for immediate manipulative reduction under an anæsthetic. Well-developed musculature, delayed reductions and malpositions are perhaps the chief factors which prevent ready reduction and demand the greatest degree of muscle relaxation. If nerve block anæsthesia should prove adequate under these conditions, its efficiency would be well established, especially in its indicated sphere where usually more favorable mechanical conditions exist.

The following are examples of the type of cases chosen to test the capability of the method for supplying adequate muscle relaxation:

CASE No. 4349.—Patient, chauffeur, thirty-five years of age, weight 210 pounds. Unusually well-developed musculature. Diagnosis—anterior dislocation of right shoulder and fracture of the greater tuberosity with marked separation. The injury was forty-eight hours old and two attempts at reduction elsewhere, had been unsuccessful. This case, presenting a patient with powerful musculature, an extreme degree of dislocation and delayed reduction of forty-eight hours would seem to present all the factors requiring a greater degree of muscle relaxation for successful reduction. A preliminary hypodermic injection of morphine sulphate grain  $\frac{1}{4}$ , was given and a brachial plexus block was done with 2 per cent. neocaine. The procedure was carried out under the fluoroscope, and the

dislocation and fracture were readily reduced by a Kocher method without any discomfort to the patient. The degree of muscle relaxation seemed to be quite as complete as one obtains with general narcosis.

CASE No. 4540.—Longshoreman, age thirty-four, diagnosis—muscular type, alcoholism, laceration of scalp and nose, fracture of nasal bones, Colles' fracture with marked dorsal displacement and impaction. Duration—twelve hours. The patient was uncoöperative, of a muscular type, a chronic alcoholic, had multiple injuries as well as a respiratory infection, and presented a combination of unfavorable mechanical factors for reduction, as well as factors contra-indicating general narcosis. A brachial plexus block was done by the supra-clavicular method with 2 per cent. neocaine. Relaxation was quite complete and the patient who, at the outset was uncoöperative, offered no difficulty or resistance to the procedure, and a successful reduction was accomplished.

CASE No. 7371.—Longshoreman, age forty-two. Diagnosis—Potts' fracture. Duration—forty-eight hours. Reduction was attempted under general anæsthesia forty-eight hours before, but was unsatisfactory because of a persistent widening of the mortise of tibio-fibular articulation and malposition of astragalus. This case presented the factor of delayed reduction in a difficult fracture. Popliteal space block was done with 2 per cent. neocaine, and fracture was easily corrected under direct vision by aid of the fluoroscope.

CASE No. 4420.—Longshoreman, muscular type, age forty. Diagnosis—Potts' fracture. Duration—three hours. This patient presented a combination of a powerful musculature with a moderately severe fracture. The popliteal space block was adequate for reduction and offered satisfactory relaxation.

CASE No. 8882.—Seaman, powerful muscular type, age sixty-five. Diagnosis—Colles' fracture with marked displacement and impaction. Duration—twenty-four hours. This patient presented the combination of a well-developed musculature and advanced age, although general excellent condition of patient would have tolerated a general anæsthetic. Fracture was readily reduced by brachial plexus block with satisfactory muscle relaxation.

CASE No. 11314.—Printer, age sixty. Diagnosis—fracture of proximal phalanx of left index finger. Duration—one week. Arteriosclerosis and chronic bronchitis. The over-riding and malposition of the fragments were such that if the position were not corrected, a disabled finger would have resulted. This patient presented the factor of delayed reduction as well as unsuitability for general narcosis. An attempt made to correct this deformity, without anæsthesia was unsuccessful. Although the fracture was a week old, a lateral nerve finger block allowed for relaxation and painless manipulations to correct the position and maintain retention of the fragments without the need of traction.

The examples cited, seemed to present those factors which would necessitate the obtaining of that certain degree of relaxation necessary before reductions could be accomplished. In these instances, the indicated nerve block procedures, as explained later, had been instituted, and the resulting muscle relaxation was, at all times so satisfactory, that any residual tonicity persisting was practically negligible. In our whole series of fifty fractures, various available procedures were tried with the idea of evaluating their merit and indications, and in some instances the resultant muscle relaxation was not as complete and satisfactory as could be desired. The related factors, some of them avoidable and others unavoidable, were recognized and will be discussed later. However, with the method not always used in the ideal manner, we were able to reduce successfully forty-nine of the fifty fractures attempted (Table II). The only unsuccessful case was a fracture of the os calcis, which could not be reduced under general narcosis and necessitated an open operation. The failure was obviously not due to anæsthesia. These uniformly successful results established to our satisfaction that nerve block

## REGIONAL ANÆSTHESIA IN FRACTURES

fulfils the second requisite of a satisfactory anæsthetic, namely, to supply adequate and sufficient muscle relaxation to cope with the mechanical factors of adaptable fractures and dislocations.

In any fracture, the obvious plan is to block the nerves proximal to the site of fracture, and, depending on that site, various levels may be available. Thus the reduction of a dislocated wrist-joint may be attempted with either a block of the median and ulnar nerves at the wrist, a block of the median, ulnar, and radial at the elbow, or a brachial plexus block. In our series, we tried these various procedures with the purpose of establishing their comparative value, and this fact in part explains some of the instances where muscle relaxation was not entirely satisfactory, although in all instances it was adequate for successful reduction. Similar types of lesions were reduced with blocks at various levels to determine the possible advantages of one procedure over another, and the following examples illustrate the factors involved:

CASE NO. 3381.—Fracture of radius and ulna—middle third. This fracture was anæsthetized by an elbow block and successfully reduced, but the arm musculature seemed to retain its tonicity and add sufficient muscle spasm to make the reduction more difficult and not as satisfactory as one would ordinarily have expected with a general anæsthetic.

CASE NO. 6757.—Fracture of shafts of radius and ulna junction—middle third and lower third was, in a sense similar in its mechanical problems to Case No. 3381. It was anæsthetized by a brachial plexus block, which eliminated the resistance of upper musculature, and the reduction was accomplished as readily and satisfactorily as could be expected.

These examples emphasize the distinct regional character of the nerve block method, and the necessity of appreciating the related factors involved in obtaining maximum results. In the elbow block, the whole musculature distal to the level is affected, while the tonicity of the arm musculature, which is not anæsthetized remains practically unaltered. In the brachial plexus block, anæsthetization involves the whole upper extremity, and degree of relaxation resulting therefrom, has proved sufficiently complete to reduce fractures and dislocations attempted without feeling the need for more relaxation.

The factor of regional anæsthetization of muscle groups and its related importance to the circumstances of the fracture, was further emphasized in a series of Colles' fractures, where the tonicity of the arm musculature would seem to be a less important source of resistance.

In Cases Nos. 3148, 4275 Colles' fracture of simple dorsal displacement and slight impaction, reductions satisfactorily accomplished with elbow block.

Cases Nos. 11270, 7418 Colles' fractures where displacement and impaction were marked, reductions were accomplished by elbow block, but tonicity of arm musculature seemed to offer sufficient generalized resistance to make procedure more difficult than would be expected with general anæsthesia.

Cases Nos. 8882, 11045 Colles' fractures comparable to Cases Nos. 11270, 7418, reductions were accomplished with brachial plexus blocks. The absence of the arm muscle tonicity, allowed for a greater generalized relaxation and more ready and satisfactory reductions resulted.

These experiences show that the maximum efficiency of the method is dependent upon the procedure instituted, which is further governed by site



and the type of fracture and general musculature of the patient. These factors must be kept in mind, not only in selecting the procedure to be employed, but also in determining the method's value and indications. In elbow fractures or dislocations, or fractures of both bones of the forearm, the arm musculature is a definite factor in resistance, and the upper level of the brachial plexus adequately eliminates that undesirable factor. In Colles' fracture or fractures at a lower level, the nature and type of fracture and general musculature become the factors in determining the type of procedure. Obviously, fractures above the elbow level must be reduced under the brachial plexus block.

The same general principles pertain in the fractures of the lower extremity, but perhaps to a greater degree, because the interrelationship of muscle groups is more pronounced, the musculature more powerful, and the reductions usually more difficult. Seldom, at this clinic, are fractures of both bones of the leg with malposition, treated by immediate manipulative reduction and plaster retention. Badly over-riding fractures of the tibia and fibula, as well as spiral fractures with potential slipping are treated by traction and suspension; *e.g.*, Steinman pin through the os calcis or calipres in the malleoli. The compound fractures necessitating débridement, and those with slight malposition may be subjected to immediate reduction under regional anaesthesia. Unless there is some definite contra-indication to general anaesthesia, nerve block is not advocated, although the adequacy of the method for these lesions was definitely established. As the procedure must be done either at the popliteal space, or by a sciatic nerve block, the tonicity of the thigh muscles is usually great enough to add to the difficulty of the reduction.

Fractures about ankle satisfactorily treated by popliteal space block, without any unfavorable, resisting muscle spasm by the tonic thigh muscles.

Case No. 7371 cited as an example of the type mechanically unfavorable to the method, a secondary reduction of a Potts' fracture forty-eight hours after an unsatisfactory reduction under general anaesthesia was readily reduced by a popliteal space block with adequate relaxation. Three other Potts' fractures were successfully reduced with adequate relaxation. Fractures of the malleoli which require only protective splinting may be painlessly handled by the popliteal space block, and thereby avoiding discomfort in the application of splints in the effort to obtain any desired positions.

Fractures and dislocations of the bones of the foot are most satisfactorily taken care of by popliteal space blocks, although metatarsal and phalangeal injuries may be handled by ankle blocks. Fractures of the os calcis which are amenable to correction or reduction should be blocked at the popliteal space to obtain relaxation of the Tendo-Achillis.

Fractures and dislocations of the phalanges, which require anaesthetics for correction have been treated very advantageously by block of the lateral nerves about the base of the finger or toe. The malposition of these lesions is not dependent upon interrelated muscle groups but mainly upon related tendons which may be sufficiently relaxed to offer no serious difficulty to the



## REGIONAL ANÆSTHESIA IN FRACTURES

reduction. The advantages of carrying out these particular smaller but important procedures without the inconvenience of general anæsthesia are obvious.

With the efficiency of the nerve block method established, its definite indications become apparent. It is obviously indicated where any of the well-known objections to the use of general narcosis exist, and perhaps the greatest field for its use obtains, where the factors demanding the maximum degree of muscle relaxation are not so formidable. The fractures of the aged, as well as those unsuited for general narcosis because of some chronic systemic condition, usually do not present a well-developed musculature, and frequently a less perfect anatomical result may be tolerated. In this class, nerve block is ideal and is the procedure of choice. In the fractures of the vigorous where any special contra-indications to anæsthesia may arise, the method may be expected to be adequate, and it then becomes the procedure of choice. Furthermore, under relatively normal conditions, it may, by a discretionary choice of case, become the procedure of preference. It spares the patient a general anæsthetic with its attendant disagreeable features and, because of the duration of the anæsthesia, the manipulations may be carried out freely and carefully under the fluroscope without haste. It eliminates the excited recovery of general narcosis with its potential harm to a satisfactory reduction, and it avoids the frequent necessary hospitalization of a patient following that type of anæsthesia. We are not prepared to contend that these advantages overbalance the general usefulness of general anæsthesia in fracture work, and we grant their comparative value must be a matter of individual discretion. However, as nerve block proved efficient anæsthetic for fractures and dislocations with undoubted indications for its use, we feel justified in claiming that in these instances it becomes an excellent adjuvant in that type of work.

In our series, which, from the view of specific anæsthetic indication, was relatively unselective, cases were encountered which more or less illustrate the indications which we think pertain to the nerve block method. The following are examples:

CASE No. F. K.—(Private) Housewife, age thirty-four; four months pregnancy. Posterior dislocation of left elbow; duration—one hour. Because of the associated pregnancy and a fair degree of general reaction caused by the injury, it was thought preferable if possible to avoid a general anæsthetic. A brachial plexus block was done with 2 per cent. neocaine and a ready reduction was accomplished with adequate relaxation and no discomfort to the patient.

CASE No. 3148.—Printer, age fifty-six. Diagnosis—Colles' fracture (left) with impaction and displacement; duration—one hour. Arteriosclerosis, emphysema and chronic bronchitis. This patient presented the factors of age, chronic respiratory condition, and the local fracture, where a satisfactory result was necessary for the successful continuation of his trade. Under ordinary conditions, as a fair functional result was conceivable, perhaps no attempt would have been made to correct this fracture, because of the necessity of subjecting the patient to a general anæsthetic. Under an elbow block, the fracture was satisfactorily reduced.

CASE No. 4412.—Age sixty-three, Potts' fracture; duration—one hour; general arteriosclerosis. This patient was senile, and it was desirable to avoid general narcosis. A popliteal space block was adequate for reduction.

CASE No. 4540.—Colles' fracture with impaction and poor position cited previously

for factors preventing ready reduction definitely indicated a "nerve block procedure," because of the acute respiratory infection, alcoholism and multiple injuries. The fracture was satisfactorily reduced with a brachial plexus block.

CASE No. 11314.—Fracture of proximal phalanx (cited previously) presented a chronic respiratory condition, arteriosclerosis and advanced age, and was reduced under lateral nerve block.

The above examples are but a few examples of the field of applicability of this method of anaesthesia.

Some consideration may be given at this time to the technical factors of the question, as the efficiency of the method is at times directly dependent on the choice of technical procedure. Our theme deals directly with the problem of a more or less well-defined clinical entity in relation to this form of regional anaesthesia, and not actually with the methods of producing any regional block. Naturally, as diversified as the lesions may be, so will the necessary technical procedures be. The discussion of the technical aspects of any of these, would require a detailed account of the local anatomy and special procedures as long as this theme itself, and is not within the province of this paper. In general, we have found no specific differences in the technical features to feel that any one procedure merited preference over another. Perhaps more concern is manifested over the brachial plexus block, because of conceivable complications attributed to it, *e.g.*, neuritis and paralyses. Thus far, in our experience, which is relatively limited, we have found the procedure comparatively simple and 100 per cent. successful, and, in our whole series, have had no infections at the site of injection or evidence of any residual symptoms suggesting nerve trauma. No authentic reported series of regional blocks have been found to estimate a percentage incidence of possible complications. We feel that these are as few, and, perhaps fewer than the more serious complications of general anaesthesia, or the untoward accidents of a lumbar puncture, paracentesis, or thoracentesis. The sum and substance of the problem resolves itself into an appreciation of the several factors involved in any particular fracture or dislocation, and the criterion for the site of any injection is not one of technical difficulties, but the obtaining of the most adequate degree of muscle relaxation.

Some routine is advisable and we have been accustomed to manage our cases in the following manner: After the usual clinical examination, the patient is X-rayed and the diagnosis established. This is usually carried out without excessive discomfort. The actual character of the fracture as determined by the X-ray finding, should be one of the factors to determine the procedure. If a block is decided upon, it is important to get the patient's confidence and coöperation by explaining the nature and advantages of the forthcoming steps. It is essential to give a preliminary sedative which dulls sensibility and apprehension. Morphine, grains  $\frac{1}{4}$ , is given immediately before injecting, and it usually has its full effect by the time the patient reaches the fluoroscopic room. It is essential to have needles that are thin, sharp, and smooth, and a syringe which is serviceable. We feel the anaesthetic agent is important, and we have preferred "neocaine," because of an apparent

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superior action, evidenced by a quicker analgesic onset and a longer duration of anæsthesia. As soon as full anæsthetization is obtained, which usually occurs in 15 to 20 minutes, the patient is taken to the fluroscopic room. We frequently allow the patients to initiate the effort of getting on the table themselves, and thus far, practically without exception, they have unconsciously attempted to use the injured member in doing so. Apparently a complete anæsthesia allows for a dissociation of their injury by some new conscious impression, and we have used this reaction as one of the signs of thorough anæsthetization, especially in the nervous and apprehensive patient who is slow in admitting the lack of discomfort. By previously manipulating the local area for the patient's attention and benefit, he is usually surprised by the lack of discomfort, and becomes more mentally assured. As the anæsthesia usually lasts one to two hours, the necessary manipulations may be carried out with ease. Positions may be examined, checked and rechecked, retention apparatus applied and adapted by the time muscle tonicity begins to return. The procedures are devoid of the shock, unpleasantness and hazards of general narcosis, need not hospitalize the ambulatory patient and may be readily carried out wherever the proper aseptic precautions may be obtained; operating room, dispensary, or private office.

### SUMMARY AND CONCLUSIONS

1. In the reduction of fractures and dislocations, instances occur where general narcosis is contra-indicated; and indicated therapy is thereby frequently disadvantageously modified.

2. Nerve block produces a regional anæsthesia without compromise to the site of fracture or dislocation and obviates that potential damage which exists with the ordinary infiltration method of local anæsthesia. Nerve block is thus surgically rational in presence of pathology associated with these lesions.

3. In series of adaptable fractures and dislocations indicating immediate manipulative reduction, nerve block was found to be satisfactory anæsthetic, by allowing painless reduction and by supplying adequate muscle relaxation.

4. Nerve block is an excellent adjuvant for use in fracture work, and is the indicated anæsthetic where any contra-indication to general narcosis exists. Because of the many decided advantages pertaining with its use under ordinary circumstances, it may readily become the procedure of preference for the reduction of fractures and dislocations.

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# TRANSACTIONS OF THE PHILADELPHIA ACADEMY OF SURGERY

*Stated Meeting Held January 3, 1927*

The President, DR. CHARLES F. MITCHELL, in the Chair

## BILATERAL CONGENITAL DISLOCATION OF HIPS

DR. J. W. BRANSFIELD reported the case of Mary B., age two years, who was admitted to the St. Agnes Hospital, November 1, 1926. Under

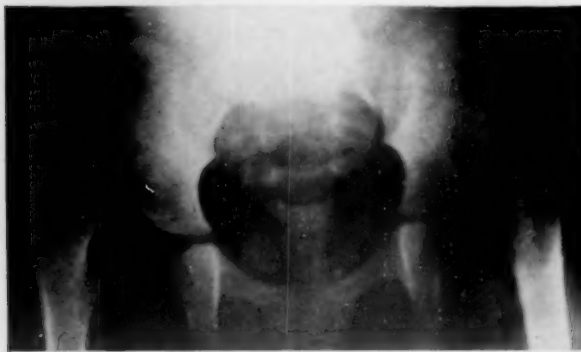


FIG. 1.—Bilateral congenital dislocation of the hips.

ether anaesthesia both hips were reduced by the closed method following the method advocated by the late G. G. Davis. The reduction was done under the fluoroscope and it was interesting to note that if the muscles are stretched sufficiently the reduction can be accomplished by any method used in an acquired dislocation. If the muscles are not properly stretched none of the fanciful movements advocated will influence the reduction. The patient was dressed in plaster and the legs were placed in the "frog" position. The case was removed in seven weeks. Fig. 1 shows the dislocation. Fig. 2 shows the dislocation reduced after the case was removed.

DR. FORREST WILLARD pointed out that the length of post-operative treatment was unusually short. In all cases which have come to his orthopaedic service, it has been found that two months' fixation does not hold it in place, and it is an unique case which will

not redislocate, after reduction, with only two months' fixation. The general time of fixation for bilateral congenital dislocation of the hip is at least eight to twelve months. Some surgeons advocate fifteen months. Doctor Willard thinks that this is too long, but that short fixation of two, three or four



FIG. 2.—The dislocation reduced.

## FRACTURE OF OS CALCIS

months is liable to later allow the hip to slip out of the socket, unless one finds a rare case in which the socket is of normal depth.

### CONGENITAL ABSENCE OF BODY OF THORACIC VERTEBRA

DR. J. W. BRANSFIELD reported the case of John A., who was admitted to the St. Agnes Hospital, October 26, 1926. The X-ray showed absence of the body of the seventh thoracic vertebra with a tilting of the spinous process of the eighth. From the history and X-ray study it was decided that this case was of the congenital variety. Under ether anaesthesia the vertebrae were exposed, and the eighth thoracic was found to be easily moved and was restored to normal position. The spinous processes of IV, V, VI, VIII and IX were split after the method of Albee and a graft obtained from the tibia was placed in the groove. The graft was held with kangaroo tendon, the wound closed and a figure-of-eight dressing applied over back and shoulders. On removing the skin clips on the eighth day, a small blood clot was found but no infection occurred. Patient is in hospital at the present time. X-ray shows the graft to be in good position.

### FRACTURE OF OS CALCIS

DOCTOR BRANSFIELD reported the case of James W., who was admitted to the St. Agnes Hospital, September 17, 1926. The patient had fallen a distance of three feet from a ladder, landing on the heel. He walked to the hospital, where the diagnosis of fracture of the os calcis was made (Fig. 3a). Under ether anaesthesia the fracture was reduced and the fragments nailed. Fig. 3b shows the nail in position. A plaster case was applied and was removed in four weeks. About six weeks after the removal of the case he complained of pain across the tendo-Achillis. X-ray showed that the nail was loose; it was removed under local anaesthesia. There has been no further disability—the patient walks normally and suffers no pain.

DR. E. B. HODGE remarked that he had a case now at the Germantown Hospital for fracture of the os calcis. This case has been treated by the method which Doctors Jopson and Speese and the speaker have been using with satisfaction. This particular fracture is a badly comminuted one but the ordinary disability in these cases is due to the pulling up of the posterior fragment. The method of treatment is by tongs which pull the posterior fragment down so that the proper angle with the anterior portion is restored. The speaker did not think that this case could have been treated by nailing. Of course, the great disability comes from flattening of the foot; this method

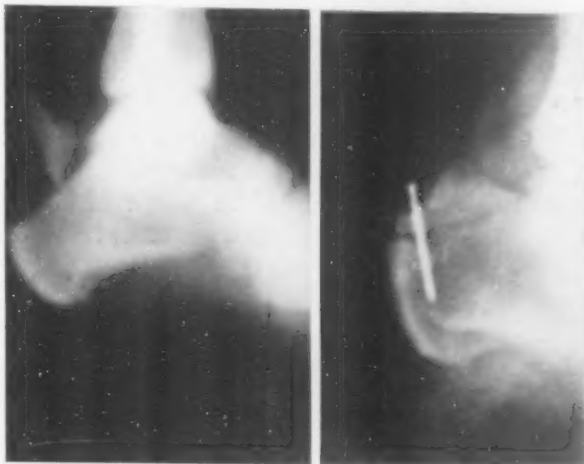


FIG. 3.—Fracture of the os calcis. *a.* Showing the fracture. *b.* The fracture reduced and fixed by nail.



of treatment has made it possible in almost all cases to bring the heel fragment down to its normal relationship with the rest of the bone.

DR. A. BRUCE GILL said that it is well known that fracture of the os calcis often produces prolonged disability. There are a number of conditions which cause this bad result or contribute to it.

The first one of these is the presence of spurs or a mass of bone on the plantar surface of the os calcis. This is due to the fact that the posterior fragment has not been reduced. On several occasions he has been obliged to cut off these spurs or masses of bone from the plantar surface and the result of operation has been satisfactory.

A second condition is a mass of bone on the external aspect of the os calcis. When the os calcis is crushed by a fall on the foot the inferior and superior surfaces are driven closer together and fragments of bone are forced out laterally. The patient complains of pain and tenderness just below and in front of the external malleolus over this mass of bone which is distinctly palpable and is also clearly shown in X-ray films. Why it should be the source of pain the speaker is not quite sure; whether because it contacts with the external malleolus on pronation of the foot, or makes pressure on soft structures as, for example, the sheath of the peroneal tendons, or, what Doctor Gill believes to be more probable, because it is at the outer aspect of the subastragalar joint and interferes with motion of the os calcis beneath the astragalus. This mass of bone presents a bone block to normal pronation of the foot beneath the astragalus. In two cases he has removed this mass of bone with very good result.

A third cause of pain and disability is a lateral displacement of the os calcis, usually to the outer side. At the time of reduction the fragments have not been replaced in their proper position beneath the astragalus. If they are displaced outward the patient has a talipes valgus and presents all the symptoms of a chronic flat foot. The same disability is produced as in a failure to reduce external dislocation of the astragalus in a case of Pott's fracture.

A fourth element in these cases of fracture of the os calcis is the involvement of the subastragalar joint in the fracture. Normal motion of this joint is interfered with by improper position of the os calcis beneath the astragalus or by new bone formation. Therefore motion is limited and it is apt to be painful. In these cases it is best to do a subastragalar arthrodesis to obliterate all motion between the os calcis and the astragalus. A little motion which is painful is much worse than an ankylosis of the joint. He had seen the same condition present in the ankle after Pott's fracture and had not hesitated to do an arthrodesis of an ankle-joint when there was not enough improvement obtained by more conservative means.

The speaker thinks that the method of reduction which Doctor Hodge employed is a very good one. Sometimes the fragments may be reduced by manipulation without the use of tongs or nail. If the knee is bent to relax the tendo-Achillis and if the foot is plantar flexed to bring the anterior

## FRACTURE OF OS CALCIS

fragment of the os calcis in contact with the posterior fragment a good reduction can thus be secured. Some surgeons tenotomize routinely the tendo-Achillis. This is not very good surgery as in some cases it may be necessary later on to suture again the divided tendo-Achillis.

Possibly a contributing factor in the prolonged pain and disability which so often accompanies these fractures of the os calcis is the fact that fixation or support of the foot is not continued long enough. After the case or splint is removed the shoe which the patient is to wear should be fitted with a steel shank and with a felt pad to give proper support beneath the arch of the foot to prevent a sagging down of the os calcis at the point of fracture, before thorough union has occurred. Frequently, too, these patients have had even before injury a valgus or a certain degree of flat foot, and this condition of pronation or flattening complicates the case by throwing a strain on the foot which has now been further weakened by fracture.

In dealing with fractures of the os calcis one must bear in mind the complete mechanics and function of the entire foot. The speaker suspects it is largely the lack of a broad point of view on the part of the surgeon which sometimes contributes to these disabilities.

DR. A. P. C. ASHHURST remarked that he had never seen a good result in a fracture of the os calcis. Doctor Gill says he has seen two or three bad results; but the speaker has scarcely ever seen a good one. It is one of the most disabling of all fractures, especially when comminution is present involving the astragalo-calcaneal joint; in this type the results are bad in about 80 per cent. of cases, after ordinary treatment. For this reason Doctor Allison, of Boston, proposed, a year or so ago, to operate on all such patients at the time of injury, doing a subastragalar arthrodesis, and not to postpone this operation until the patient had passed through a long period of invalidism. The pain and disability which follows the injury is due to distortion of the upper weight-bearing surface of the calcaneum, rather than to changes on its plantar surface, though the latter may also cause disability. Doctor Allison has operated on more than twenty-five recent cases of fracture of the calcaneum in this way. About 85 per cent. secured good function, and the average period of disability has been twelve weeks. It is therefore a method of treatment which demands attention.

DR. JOHN A. JOPSON said that he was not sure whether Doctor Speese or himself first used tongs traction in fracture of the os calcis. The method is a perfectly simple one. There may be other methods as good or better, but this fulfils the requirements and is simple of execution.

The knee should be bent and the best way is to put it in a Thomas splint with a bend at the knee. And then, as always when using tongs, one has to be careful of the landmarks and should not put the tongs in a position where they will do harm. In fracture of the os calcis, through the tuberosity, it is important that the tongs be in a proper position to make traction; also a small pair of tongs should be used.

The speaker demonstrated this method before the College of Surgeons and

## PHILADELPHIA ACADEMY OF SURGERY

Doctor Cotton, of Boston, who was present, stressed the importance of lateral moulding and manipulation to overcome the lateral displacement of

the main fragment or separate fragments—a point on which he lays great stress; with this modification he has continued to use the method and reports that it has proven very satisfactory.

As in all fractures it is important to get the fragments down in position at the earliest possible moment.

### PULSATING EXOPHTHALMOS

DR. THOMAS A. SHALLOW reported the case of a man, age thirty-four years, who was admitted in the Jefferson Hospital, December 3, 1925, to the Ophthalmological Department of Dr. William M. Sweet. On admission this patient exhibited protrusion of both eyes, most marked in the right eye. In addition he complained of a headache accompanied by buzzing sounds. He gave a history of having been struck on the head November 7, 1924, while riding in an automobile. He was found unconscious some hours later lying in the road and was taken to a hospital in New Jersey. The unconsciousness lasted for twelve hours after he had been taken to the hospital. During the



FIG. 1.—Showing the appearance of bilateral exophthalmos more marked in the left eye. At the time of this photograph no subjective bruit was heard.

course of the unconsciousness and for four weeks thereafter he had a constant dripping of blood from the left ear.

Six weeks after the accident he noticed that his left eye was turned

## PULSATING EXOPHTHALMOS

upward. This was in the latter part of December, 1924. Within a day or two after he had noticed the turning upward of the left eye, both of his eyes became prominent, the protrusion being more marked in the left eye (Fig. 1). His vision was much impaired in the left eye. He was sent to a hospital in Philadelphia for this condition and a plastic operation upon the conjunctivæ performed. During the following months both eyes were very prominent and about equal in size. In August, 1925, the left eye began to very slowly recede.

In May, 1925, he noticed a peculiar humming noise in his head. This was aggravated on stooping and bending the head forward. He also complained of a peculiar noise in the left ear.

His first admission to the Jefferson Hospital was on December 3, 1925. Examination showed that both eyes were quite prominent, the right eye more so than the left. The conjunctivæ of both eyes was very redundant and chemotic. A well-defined continuous bruit was audible to the clinician over the right frontal sinus and over the right eyeball, and could also be heard indistinctly over the left frontal sinus. The bruit while continuous was accentuated during systole. The pupils of both of the eyes were dilated and reacted sluggishly to light.

Eye ground examination: Bilateral exophthalmos. The right eye protrudes 6 mm. beyond the left eye. The optic nerve of the right eye is blurred at the edges and there is some hemorrhagic destruction of the retina. The veins are tortuous and the artery is small. The vision is 10/100. The left eye. The protrusion is not quite so prominent as of the right eye. Vision 20/40. The optic nerve is fairly healthy.

X-ray examination by Doctor Manges shows that the sella turcica is normal. There is no pathology in the bones of the skull to account for the exophthalmos.



FIG. 2.—Showing the recession of the left eye following ligation of the right common carotid artery and persistence of the exophthalmos in the right eye in spite of ligation of the right common carotid artery.



Medical examination by Doctor Thomas McCrae did not elicit anything in the patient's general physical condition to account for the exophthalmos.

This case presented several unusual features. It is stated by writers that bruit is the first symptom of an arteriovenous fistula. This patient first complained of buzzing noises in his head in May of 1925, six months after the accident. On questioning his father after the death of the patient, it was learned that his son frequently asked him if it was raining because he thought he heard rain. This symptom disappeared after his discharge from the hospital. The patient himself stated positively that he did not have any noise in the head until May of 1925.



FIG. 3.—Showing aneurism between the right cavernous sinus and the internal carotid artery. The injection was made through the left carotid artery proving the reversal of the circulation through the circle of Willis into the aneurism. The reversal of current is the reason for failure of cure by ligation on the side of the fistula.

The next unusual condition in this case is a bilateral exophthalmos. There are cases on record of arteriovenous fistula in which bilateral exophthalmos occurred, but when it was noted in this case it began in the eye on the same side as the fistula and later extended to the other eye. The bruit could be heard and the thrill could be felt most strongly in the right eye. Dr. J. Chalmers DaCosta believed that the pathology was on the right side between the internal carotid artery and cavernous sinus. In this history

the left eye was the first organ to become prominent and remained more prominent than the right eye for a number of weeks. It is hard to explain how a lesion on the right side could be manifested first by exophthalmos on the left side unless it is assumed that the fistula is on the mesial side of the internal carotid artery in the region of the circular sinus and the stream of the current passes directly across the circular sinus to the left cavernous sinus and thence into the left superior ophthalmic vein, causing left-sided exophthalmos (Fig. 1). After the pressure had risen sufficiently to practically cut off vision in the left eye. Within one week after the left eye protruded the right eye began to manifest exophthalmos. The examination of the patient made in December, 1925, over one year after the accident, showed a beginning subsidence of the left exophthalmos. It is to be recalled that Doctor Sweet stated in a previous examination that the right eye protruded 6 mm. more than the left.

In spite of the manner of onset of this condition, that is the appearance first in the left eye, it was decided that the lesion was between the right internal carotid artery and the cavernous sinus, because of the location of the bruit on the right side, and, on January 8, 1926, the reporter ligated the right common carotid artery. Upon ligation, while the patient was still on the



## PULSATING EXOPHTHALMOS

operating table, the bruit immediately ceased. From the time of the operation to January 24, there was a rapid diminution in the protrusion of the left eye and a more gradual diminution in the protrusion of the right eye. The patient did not complain of the bruit nor could one be heard by us over the right frontal bone. There was no palpable pulsation of either the right or the left globe.

On January 25, a very faint systolic bruit could be heard in the right eyeball. On January 31, this bruit was continuous and could be readily heard over the right frontal sinus. The right eye which had been receding became stationary and remained slightly exophthalmic. The left eye continued to recede.

An ophthalmological examination made February 28, showed that the left eye ground was almost normal and that the man was now able to read fine print. Right eye: Optic nerve was blurred at the edge and there was some exudate in the retina. Vision 10/100.

The patient was discharged from the hospital, February 28, 1926.

The patient was lost track of for a number of months. He came under observation again in November of 1926. The left eye was almost normal in size. The right eye showed decided exophthalmos. At this time he had a distinct thrill which would be felt in the superficial veins along the inner angle of the right orbit. A continuous bruit could be heard over the right frontal sinus and the right eyeball (Fig. 2). There was a definite pulsation in the right internal carotid

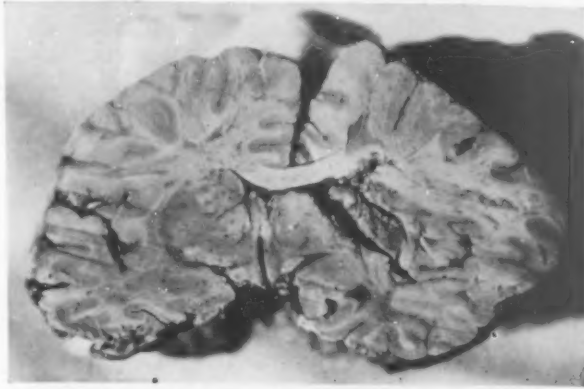


FIG. 4.—Showing the area of necrosis of the left hemisphere of the brain.



FIG. 5.—Showing the distribution of the bismuth in all of the ramifications of the left common carotid artery in contrast to the almost imperceptible distribution of the bismuth on the right side except in the right internal carotid artery.

continuous bruit could be heard over the right frontal sinus and the right eyeball (Fig. 2). There was a definite pulsation in the right internal carotid

artery. It was thought at this time that the right common carotid artery had become cannalized and that the blood was passing through the right common carotid artery which had been ligated but not cut across. Closer observation did not disclose any pulsation in the right external carotid artery or any of its branches. It was concluded from that that blood was not passing into the right internal carotid artery from below nor from any collateral circulation established through the right external carotid artery. The presence of the blood in the right internal carotid was considered as due

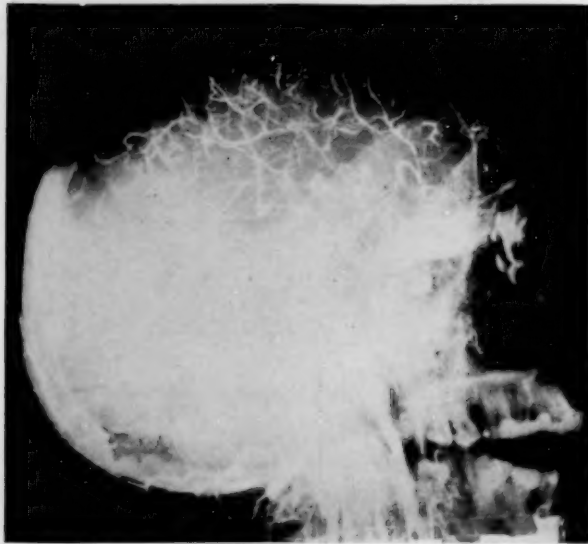


FIG. 6.—Showing the enormous distention of the superior ophthalmic vein and its branches on the side of the fistula.

to a reversal of current, the blood descending into the vessel (internal carotid) from the Circle of Willis. The blood was descending in the right internal carotid and not ascending. The patient was readmitted to the Jefferson Hospital to Doctor Sweet's service. Pressure on the left common carotid artery cut off the circulation in the right common carotid artery. Upon the release of this pressure the patient stated that objects were dancing in front of his eyes. This phenomenon continued for a second or two. In view of the

fact that the circulation could be cut off in the right internal carotid artery by compression of the left common carotid artery, ligation of the left common carotid artery was decided upon.

December 18, under ether anaesthesia, the left common carotid artery was exposed and drawn into the wound. A Crile clamp was applied to this artery. Through a stethoscope applied over the right frontal sinus and right eyeball, with the clamp in place, a very faint systolic bruit could be heard. No thrill could be felt in the superficial veins of the right orbit. In the right internal carotid artery there was no pulsation present. This proved conclusively that the current was reversed in the right common carotid artery. The reporter, therefore, ligated the left common carotid artery with the hope of curing the aneurism. Within two hours after the operation the patient became very restless and slightly irrational. No pulsation in the right internal carotid artery or the right external carotid artery could be felt. The bruit over the right forehead was very faint. No thrill could be detected in the region of the right eye. The patient developed on the third day weakness of the right arm and leg. He became comatose twelve hours before death and died six days after the ligation of the left common carotid artery.

*Post-mortem Examination.*—The left common carotid artery was injected with a bismuth solution to determine the question of the route of the blood. An X-ray examination of the head was then made and it showed the bismuth in the left common carotid artery and in the aneurism, which was on the right

#### PURULENT PERICARDITIS IN CHILDHOOD

side and in the right common carotid artery (Fig. 3). A very thin trickle of blood could be seen in the right external carotid artery. The X-ray also disclosed that the right half of the brain was not injected with the bismuth throughout the course of the right internal carotid and its branches, and it was, therefore, concluded that the circulation had been reestablished through the anterior communicating branch over the anterior cerebral artery of the left side directly into the left common carotid artery. Examination of the brain showed an area of softening in the left hemisphere in the region of the temporo-sphenoidal lobe (Fig. 4).

The reporter concludes from this case that the surgical procedure in the treatment of traumatic arteriovenous fistula, associated with exophthalmos, should be the ligation of the common carotid artery on the side of the lesion. When this procedure fails it is because of the development of reversal of current in the aneurismal sac and along the course of the internal carotid artery, the blood coming from the opposite side (Fig. 3). Any further surgical intervention should be limited to ligation of the superior ophthalmic vein on the side of the lesion (Fig. 6). Ligation of the opposite common carotid artery being unjustifiable because of the likelihood of necrosis and subsequent softening of the brain on the side of the last ligation (Fig. 4) and because of the great diminution of circulation in the vessels of the brain on the side of the first ligation as shown in this case by the X-rays (Fig. 5).

#### FURTHER OBSERVATIONS ON SPINAL ANÆSTHESIA WITH ANHYDROUS COCAIN IN 500 CASES

DR. J. RALSTON WELLS read a paper with the above title, for which see p. 757.

DR. J. S. RODMAN called attention to two points which seemed to be of more interest than others. One of the great difficulties about cocain has been its toxicity, but apparently Doctor Wells by his present method has been able to largely overcome that difficulty. The other point brought out was the fact that cocain was the only anæsthetic that sought out the sensory nerves alone. The speaker had a rather unpleasant experience once with stovain, one patient developed bladder paralysis for about ten days and another developed partial paralysis of the lower limbs for one week. This had made him cautious about the use of stovain. Doctor Wells has given this type of anæsthesia for the speaker in twelve cases and it has proven very satisfactory. Doctor Rodman feels that it has reached the point where it is safe to use it when indicated.

#### PURULENT PERICARDITIS IN CHILDHOOD

DR. ERNEST G. WILLIAMSON read a paper with the above title, for which see p. 659.

DR. JOHN H. JOPSON asked that Doctor Williamson include in his series another case from the Children's Hospital in which the speaker drained the pericardium for suppuration but failed to save the child's life.

DR. J. W. BRANSFIELD remarked that he had presented a patient before the Academy two years ago, who had a suppurative pericarditis following a stab wound. He resected two ribs at the costochondral junction. The patient made an uneventful recovery.

DR. J. S. RODMAN said that ligation of the internal mammary artery is now a routine procedure in pericardiotomy, but that in one case, some years ago, he failed to do this and lost the patient from secondary hemorrhage; the patient dying before anything could be done. This patient had pyæmia in addition to the pericardial infection.

DR. A. P. C. ASHHURST mentioned a case, the only one of its kind he ever encountered. In December, 1924, a boy ten years of age, was treated at home by a practitioner who thought the child had a pericardial effusion; he called as consultation a specialist, who introduced a needle, but got nothing; the puncture was repeated three times, and got nothing until the fourth puncture, when blood was obtained. The consultant then withdrew the needle and retired from the case. The patient immediately became much worse, and was brought to the hospital the next day, by the family physician. There were the usual signs of massive pericardial effusion, and severe secondary anæmia. It was evident that the child had been bleeding into the pericardium. Under local anæsthesia an incision was made and the pericardium found full of old and disorganized blood, which was ejected in violent spurts. The patient improved as the blood flowed, and after nearly two litres had been evacuated the pericardium seemed dry. There was no bleeding from the heart at this time; presumably the pressure of the pericardial contents had allowed the puncture of the heart to heal. A rubber catheter (No. 16) was left in the pericardium as a drain. The child, who had seemed almost moribund before operation, was remarkably improved on return to bed, and asked for some ice-cream. The next day, however, he gradually failed; there was no bloody drainage, but death (which occurred thirty hours after operation) seemed due to secondary anæmia.

After death the wound was explored by Doctor Hicks, the ward surgeon, who found a little bloody serum in the pericardium, and the heart contracted in systole.

DR. HENRY P. BROWN said that when the correct diagnosis of suppurative pericarditis is not made, it is usually because it has not been considered. The incision should be made in the lower part of the pericardial cavity. It should be borne in mind that the diaphragm is usually one rib lower in the adult than in the child. The sinus must be kept wide open; a free incision into the pericardium with adequate tube drainage is the best, the edges of the pericardial incision being sutured to the muscle or skin. The case reported by Doctor Williamson developed a sterile effusion in the right pleural cavity, which cleared up after three aspirations. The reason for the development of this collection could not be discovered.

# TRANSACTIONS OF THE NEW YORK SURGICAL SOCIETY

*Stated Meeting Held January 26, 1927*

The President, DR. WALTON MARTIN, in the Chair

## CARCINOMA OF JEJUNUM

DR. CONSTANTINE J. MACGUIRE, JR., presented a woman, forty-two years of age, who was admitted to St. Vincent's Hospital, March 20, 1916, suffering from pain in the epigastrium immediately after meals; eructation of gas and bitter fluid; occasional vomiting; loss of twenty-five pounds of weight in nine months. The onset had been two years previously when the patient felt pain in the epigastrium, temporarily relieved with diet and bicarbonate of soda, but for a year there had been progressively increased constipation, pain and vomiting.

Gastro-intestinal X-ray series showed impairment of gastric motility; considerable deformity of the duodenal bulb and a definite deformity of the third portion of the duodenum which did not at any time fill out normally. Other laboratory findings were negative except acetone in the urine.

The patient was kept on a Sippy diet which failed to relieve her symptoms so, on April 15, 1926, she was operated upon with the following findings:

About five inches from the duodeno-jejunal angle there was a mass involving the jejunum, transverse mesocolon and the posterior surface of the transverse colon. At this point the jejunum was acutely angulated. The mass was not attached to the posterior abdominal wall and was freely movable. It was hard, nodular and about 6 cm. in diameter. Retroperitoneal nodes at the root of the mesocolon and mesentery were palpable. No metastases were felt in the liver. The stomach showed no evidence of ulceration. Periodically, there would be a contraction of its entire length, reducing its diameter by half. On separating, by blunt dissection, the jejunal mass from the transverse mesocolon it was found that there had been two openings in the jejunum protected only by the mesocolon and the posterior surface of the colon, so that after dissection the lumen of the jejunum was exposed in two places, not as result of dissection, but because of an old chronic process.

The involved portion of the jejunum was excised well beyond the diseased area, proximally and distally, and an end-to-end anastomosis of the jejunum performed. This left the anastomotic line within one inch or so of the duodeno-jejunal angle.

Pathological report by Doctor Curphey of the excised specimen is as follows:

Specimen consists of length of small intestine measuring 10 cm. The wall is held rigid in its central portion by the presence of an annular tumor mass extending up and down the gut for a distance of 4 cm. Section through the mass shows opaque white homogeneous tissue with evidence of superficial ulceration of that part directed toward the lumen. Sections show sheets of undifferentiated epithelial cells having large oval hyperchromatic nuclei, many showing mitosis lying for the most part in the mucous and submucous coats, but also infiltrating the muscle to a lesser extent. Numerous plasma cells, lymphocytes and eosinophiles are present in the muscular coats and lie also



## NEW YORK SURGICAL SOCIETY

among the tumor cells in the inner coats of the gut. Medullary carcinoma of jejunum.

Recovery was uneventful and has been followed by complete relief of subjective symptoms up to present.

This case is presented because of the rarity of the condition. Ewing in his text-book says that the small intestine is the primary site of about 3 per cent. of intestinal cancers, but at Bellevue Hospital in a recent analysis of about 600 deaths from cancer in a total of 1700 autopsies there was not a single case classified as carcinoma of the jejunum.

DR. DEWITT STETTEN said that he had never seen a case of carcinoma of the jejunum, but that he had seen a carcinoma very close to the jejunum, namely in the transverse duodenum. Some years ago he had been asked by the Medical Service of the Lenox Hill Hospital to operate on a man suffering from jaundice. A presumptive diagnosis of either cholelithiasis or carcinoma of the papilla of Vater or head of the pancreas had been made. The patient was given a dose of castor oil in preparation for the operation on the following day, and developed a severe gastric and intestinal hemorrhage. No operation was performed and the patient died within forty-eight hours. Post-mortem examination showed an extensive carcinoma of the transverse duodenum.

## RECURRENT ULCER OF JEJUNUM

DR. CONSTANTINE J. MACGUIRE, JR., presented a man who was admitted to the First Surgical Division of Bellevue Hospital, December, 1923, suffering with a duodenal ulcer. Posterior gastro-enterostomy was performed, giving entire relief for nine months when pain and tenderness recurred, but this time it did not come on until five hours after meals and was situated above and to the left of the umbilicus. X-rays showed an ulcer of the jejunum, and in May, 1925, a second operation was done. He resected the jejunal ulcer, removed all the stomach from a point proximal to the gastro-enterostomy and including the first portion of the duodenum. The jejunum had been divided in resecting the ulcer so the distal arm of the jejunum was anastomosed to the open end of the stomach and the proximal jejunum planted in the distal loop lower down. This procedure gave relief for only three months when pain again developed. Subsequently there were several severe hemorrhages from the stomach, blood count showed only 2,400,000 blood cells, with 40 per cent. hæmoglobin. Careful and prolonged treatment by alkalies, bismuth, rest in bed and careful regulation of diet gave no relief. In May, 1926, he was shown to this Society as a very unsatisfactory result after extensive resection. No definite therapeutic measures were suggested at that time. In June, 1926, the patient was so miserable and incapacitated that he consented to a third operation which had been advised with some trepidation because of the man's marked anemia and also because of the technical difficulties. As regards the latter, he was not disappointed as the adhesions were very dense and troublesome. The anastomosis between the stomach and jejunum was œdematous and indurated with extensive ulceration of the mucosa at the lower angle. The gastro-jejunosomy was excised *en masse* with the efferent loop of jejunum down as far as the jejuno-jejunosomy and the continuity of the gut at this point was restored. A loop of jejunum about eight inches distal to this was brought up and anastomosed to the stomach by the posterior Polya method. The patient made a good recovery and since his discharge has been free from untoward

## CARDIOSPASM

gastric symptoms and has steadily gained weight and strength so that he is able to resume all his duties as Captain of a Barge. A recent gastric analysis showed total acidity 45, free Hcl. 25. At the time of his first admission gastric analysis showed total acidity 90, free Hcl. 75. His case is shown as demonstrating the following points:

1. Failure of subtotal gastrectomy to control acidity.
2. A modified Polya operation using method recommended by Moynihan was followed by an extension marginal ulceration. It seems logical to conclude that the alkaline duodenal contents passed on below through jejuno-jejunostomy and left the anastomotic arm above unprotected from the full effect of the acid gastric secretion this indicating a grave physiological error in the operation.

DR. RICHARD LEWISOHN remarked that the patient had recurrent ulceration such a short time after a sub-total gastrectomy. Doctor MacGuire performed the sub-total gastrectomy according to the method of Roux "en Y." Although Moynihan uses this method to the exclusion of all others and reports good results, Haberer has reported recurrent ulcers following this method. Another interesting point was that it was never possible to establish in this patient complete absence of free hydrochloric acid. It is still a mooted question whether or not there are differences in the location of the acid glands in different stomachs. In investigating the cases of sub-total gastrectomy at Mount Sinai Hospital it was found that in all cases of gastric ulcers, achlorhydria had been established, whereas in duodenal ulcers only 66 per cent. showed absence of free hydrochloric acid.

DOCTOR MACGUIRE, in closing the discussion, said that at Bellevue Hospital their choice of method in gastric surgery was frequently forced by circumstances and they had not yet been able to take any definite stand for or against the radical school. It seemed to him that this problem must always be a physiologic one. They were obliged, however, to do many sub-total gastrectomies because of mechanical factors.

## CARDIOSPASM

DR. ALEXIS V. MOSCHOWITZ presented a man, now forty-seven years of age, who was referred to him in November, 1924, with a history of slowly increasing difficulty with deglutition, which began about ten years ago, so that at the time of his first visit he could swallow only liquids, and even that with considerable difficulty and with frequent regurgitation. He had lost considerable weight, and quite naturally a tentative diagnosis of a carcinoma of the cardiac end of the stomach was made. X-ray examination showed a stricture of the cardia. He was cesophagoscoped by Doctor Yankauer, who did not find a tumor. The patient refused operation at this time. Subsequently, the difficulty with swallowing increased so much that by the early part of March, 1925, he could not swallow even fluids.

The X-ray examination in November, 1924, showed a thin stream of bismuth passing through the cardia. The X-ray examination just before the operation failed to show bismuth passing through the cardia and a stomach tube was also arrested completely at the cardia.

March 4, 1925, he was operated upon by incision through the upper part of the left rectus. The stomach was withdrawn from the abdominal cavity and

an incision made upon its anterior surface sufficient to admit the hand. It was rather difficult to find the cardia from the gastric side, but was finally accomplished. It at first barely admitted the tip of a finger, but subsequently was dilated until it easily admitted four fingers. The gastric incision was now completely closed.

In view of the bad history, he was afraid to leave the patient in this condition and therefore added in another part of the stomach a gastrostomy, which was performed by the Kader method.

Feeding, at first liquids, gradually increasing to solids, was begun on the third day after operation and patient has been able to swallow without difficulty ever since that time. From time to time when the bolus is very large, he has to wash it down with a little water.

The patient subsequently changed his gastrostomy tube and inadvertently was given one much larger than the customary one. When Doctor Moschcowitz was ready to permit closure of the gastrostomy, the opening was so large that it failed to close. Since then the opening has contracted until it is now barely visible, although it occasionally leaks a drop or two even now.

The patient has gained about sixty pounds and is now in excellent condition.

#### OSTEOMYELITIS OF THE PUBIC BONE

DR. ALEXIS V. MOSCHCOWITZ presented two cases as follows:

CASE I.—A man forty-nine years of age, was admitted to Mt. Sinai Hospital the first time, July 2, 1922, complaining of pain in the perineum of five days' duration. He gave the following history. Five days prior to admission, the patient who is a machinist, inadvertently sat on the point of an oil can and caused thereby a punctured wound of the perineum. The injury was followed by hæmaturia which lasted two or three days. He was treated conservatively, at first, although a blood culture taken July 4 and 8 revealed the presence of four colonies of staphylococcus aureus, but the infection progressed more and more, and finally, sixteen days after admission an enormous abscess which surrounded the rectum was evacuated. He was discharged September 19 with a long sinus, into ambulatory treatment.

The sinus failed to heal and he returned to the hospital, November 8, 1926, at which time there existed several sinuses in the perineum and scrotum. These sinuses intercommunicated and when injected with lipiodol and X-rayed showed numerous ramifications, and a suspicious osteomyelitis of the pubis.

He was operated upon November 18, 1926, a liberal incision was made and when explored, the wound was found to lead to the posterior surface of the pubis to a sequestrum which was very readily removed, although with some difficulty because of its location. With the exception of a rather intractable dermatitis, he made an excellent recovery and was discharged December 27, 1926.

CASE II.—A man was admitted to the hospital in February, 1921, complaining of fever of nine days' duration. He gave a history of having had an infected finger three weeks previous to the onset of his present illness, which was accompanied by chills and fever. His physical examination showed a tender left lobe of the prostate with infiltration of the surrounding tissues. A blood culture taken at that time, showed on two occasions two colonies staphylococcus aureus per c.c. blood. The temperature was of the septic type.

He was operated upon by Dr. A. Hyman, perineal section and evacuation of a large abscess in the region of the prostate extending upward on the left side of the pelvis. Subsequently, various perirectal and rectal collections of pus, as well as a large abscess on the right side of the thigh were evacuated. He was discharged in May, 1921, with various sinuses which intercommunicated.

#### EXCISION OF RIGHT SUBCLAVIAN VEIN FOR BACTERIEMIA

In this condition, he was admitted to the service of the reporter in October, 1921, with various sinuses as above stated. The X-ray examination at this time revealed a sequestrum in the ascending ramus of the left pubic bone. He was operated upon through an incision three inches in length over the left half of the symphysis pubis and an opening made into the pubic bone. A sequestrum one-half inch by one-quarter lying in a cavity of unhealthy granulations in the centre of the bone, was removed. The entire wound was packed wide open. The post-operative course was most satisfactory and in a few weeks all of the perineal, pubic and thigh wounds were closed, so that the patient was discharged perfectly well in February, 1922.

The third admission was October, 1926, when the patient complained of pain and swelling at the site of the old perineal wound. After temporizing for a while, an abscess formed which was incised and drained. The examining finger felt an area of bare bone at about the junction of the descending ramus of the pubis with the ascending ramus of the ischium, but it evidently covered over as the wound completely healed in three weeks' time.

#### EXCISION OF RIGHT SUBCLAVIAN VEIN FOR BACTERIEMIA

A man twenty-eight years of age, was admitted to Mt. Sinai Hospital, December 16, 1926, with a history that about six weeks prior to his admission, he had a boil or an abscess about the middle of the right axilla. This abscess was incised about one week later by his attending physician, who dressed the wound for about a week and advised that the patient dress it himself. Shortly thereafter, the patient began to complain of pain in the supraclavicular as well as suprascapular region. On the day before admission to the hospital, he had a chill and a rise of temperature; when admitted, his temperature was 103.

The physical examination revealed in the right axilla, a reddened, not particularly tender area about the size of a 50 cent piece, in the centre of which, there was a small opening which admitted a probe to an inconsiderable distance. Glands could be palpated high up in the axilla and in the supraclavicular fossa.

A diagnosis of a subpectoral abscess was made, a blood culture was taken and the sinus in the axilla enlarged so as to admit exploration. No true subpectoral abscess was found, but all of the glands were found to be œdematous.

The following day, the patient felt somewhat better, but complained of pain and tenderness, particularly in the right supraclavicular fossa. The temperature fell slightly.

December 18, the swelling of the neck and tenderness in the right supraclavicular fossa had increased. The blood culture taken December 16, was reported to contain Gram-positive cocci in chains and bunches. (There was some argument about the presence of bacteria at this time in the culture, but the final result proved to be positive.) This morning, the patient had a chill and rise of temperature to 105.2. The axillary wound was revised so as to expose widely the subpectoral space by a complete division of the pectoralis major. Nothing more than œdema and swollen glands was found.

When the infraclavicular portion of the subclavian vein was exposed, it looked grayish-white and infiltrated and did not empty and fill with respiration. He therefore divided the clavicle and subsequently, in order to gain space excised about three inches. The internal jugular vein as well as the terminal  $\frac{1}{2}$  inch of the subclavian vein was normal and flaccid. A catgut ligature was now placed around the subclavian vein at its junction with the internal jugular vein. The subclavian vein was aspirated with a fine hypodermic needle and cultured. This showed both in culture and smear, streptococcus viridans. The



vein was now excised downward and upward, until a healthy part of the axillary vein was encountered. The cephalic vein and all the other branches were ligated as encountered. The excised vein showed on pathological examination a phlebitis, periphlebitis with an organizing parietal thrombus. The divided pectoralis major was sutured and a liberal rubber dam drain inserted.

After the operation, the temperature fell abruptly to 99, but on the following day, December 19, the temperature rose again to 104.6, there were no further chills, however, and the temperature fell by lysis and reached 100 in three days.

There was considerable infection of the wound, but the patient made a very excellent recovery. At no time was there more than a passing and barely noticeable edema of the hand and arm.

He had not been able to examine the literature more than casually, but this superficial examination failed to reveal a case of extirpation of the subclavian vein for sepsis.

DR. DEWITT STETTEN considered this a most remarkable case, the results of which have given him courage to undertake this step himself in similar cases. It has especially shown him that there is no need to worry about subsequent circulatory disturbances in the upper extremity. Some years ago he had a case of septic phlebitis of the axillary vein and probably the subclavian vein following a rather insignificant infection of a finger with a secondary epitrochlear abscess. Consultation was held with Dr. Joseph A. Blake and the question of ligating the axillary or subclavian vein was very seriously discussed, but the idea was finally abandoned. The child later developed a streptococcic empyema and died.

DOCTOR MOSHCOWITZ, in closing the discussion, spoke of a case he had a few years ago, very much like the one reported by Doctor Stetten. The patient had a suppurating epitrochlear gland. When this was operated upon a thrombosis of the brachial vein was seen. The incision was therefore extended upward and the vein ligated, apparently above the site of the thrombus. The patient developed a bacteræmia with a positive blood culture. Doctor Blake was called in consultation and the question of ligating the axillary or subclavian vein was discussed, but was not done because of lack of courage. The patient died.

#### CHRONIC HYPERTROPHY OF THE STOMACH WITH A REPORT OF TWO CASES AND WITH A DISCUSSION OF LINITIS PLASTICA

DR. KIRBY DWIGHT read a paper with the above title for which see page 683.

DR. HENRY H. M. LYLE said that in studying the subject for his paper on linitis plastica (*ANNALS OF SURGERY*, November, 1911), his impression was that this condition of the stomach is very often a local manifestation of a general sclerotic process. Many of his cases had lesions elsewhere and not a few were associated with adhesive peritonitis. A large per cent. of the autopsies showed an associated cardiac disease and other connective tissue lesions throughout the body. His own patient, operated on in 1907, had a very marked cardiac condition and finally died from it.



## CHRONIC HYPERTROPHY OF THE STOMACH

DOCTOR LYLE at this time wrote to Professor Welch regarding his views on the benignity of this lesion and in a personal communication, Professor Welch expressed his relief that there was a benign lesion; stating, however, that many of the cases of so-called linitis plastica were malignant.

DOCTOR LYLE has been following this subject closely since 1907 and is thoroughly convinced that there is a true linitis plastica which is benign in nature.

DR. JOHN A. McCREERY presented a specimen of a case of linitis plastica (Figs. 1 and 2) as he believed it had a bearing on Doctor Dwight's paper. Patient was admitted to Bellevue in December, 1926, a woman forty-three years old, with a history of loss of appetite and loss of strength extending over a period of two and a half years. For a few weeks previous to admission there had been epigastric pain coming on shortly after meals and accompanied by vomiting.

The patient was a well nourished adult woman who showed evidence of moderate loss of weight, but who was not cachectic. On physical examination a firm cylindrical mass could be



FIG. 1.—Specimen of linitis plastica, transverse section; note attached spleen.

felt extending the epigastrium. This was considered to be the pyloric portion of the stomach. X-ray revealed a markedly contracted stomach with a very narrow lumen through which bismuth passed without peristaltic action. The œsophagus was dilated. A pre-operative diagnosis of linitis plastica involving the entire stomach was made and confirmed at operation. A complete gastrectomy following the method outlined by Moynihan was done; the spleen being removed with the stomach because a contracted and thickened gastro-splenic omentum made this the easier procedure. The immediate post-operative reaction was satisfactory, but four days after operation the patient developed signs of a pulmonary infarct and died twelve hours later.

Autopsy showed a complete obliteration of the subclavian vein. Histologically this proved to be an organized thrombus. Emboli were found in the pulmonary vessels supplying the infarcted lung. There was no evidence of malignant disease except at the lower end of the œsophagus where microscopic evidence of carcinoma was found. The anastomosis was intact, but there was a small amount of peritoneal exudate about it. Examination of the stomach revealed a cylindrical organ measuring 18 x 4 cm. The lumen held 12 c.c.

The wall of the stomach was thickened to an average of 1.5 cm., apparently by a fibrous tissue thickening of the sub-mucosa and muscularis. The mucous membrane was intact throughout. Microscopically there was a marked fibrous tissue thickening of the sub-mucous and muscular layers while the sub-mucosa was diffusely infiltrated with an undifferentiated embryonal type of epithelial cell. This malignant change extended into the oesophagus beyond the line of division. The adjacent lymph glands showed two different types of involvement; in some the lymphoid tissue was in part replaced by broad branching strands of epithelial cells, while others presented only a few scattered epithelial

cells buried in fibrous connective tissue and fat which had replaced the normal lymphoid structure.

DOCTOR MCCREERY presented this specimen as of interest in connection with Doctor Dwight's paper. He thought that this was a case of generalized linitis plastica of malignant origin, one of the cases of which Ewing spoke, of a recessive type of carcinoma with a slow growth rate and with a



FIG. 2.—Specimen of linitis plastica, external appearance.

high resistance on the part of the patient. The varying pictures in the lymph glands were of particular interest, showing the attempt to localize and destroy the epithelial cells by the development of surrounding fibrous tissue.

DOCTOR DWIGHT, in closing the discussion, agreed with Doctor Lyle that there were undoubtedly various and different causes for a condition of the stomach, in appearance identical with linitis plastica. It is entirely a question of definition. The present tendency to narrow the meaning of the term to that of malignancy is perhaps to be regretted, for as a consequence there is a decided trend toward the merging of linitis with the other forms of diffuse carcinoma of the stomach. Also the non-malignant cases of diffuse thickening of the stomach wall have lost the name under which they have been classified in the past, and there is now a tendency to overlook them. Some of these benign cases may be the effect of a constitutional disturbance, as those in which there is, coincident with the gastric condition, some disease of the heart; or those in which there is a multiple linitis of the stomach and various parts of the large or small intestine. Ewing considers that this latter condition may be an example of polyserositis, but it must not be forgotten that certain of them have been proved malignant.

## BRIEF COMMUNICATION

### TRANSTHORACIC ABDOMINAL HERNIA

H. L., MALE, laborer, aged thirty-five, entered Barnes Hospital in July, 1926, complaining of a painful lump in the left chest. His family history was irrelevant. He had been in the German army during the late war and had been wounded several times, but never in the chest or abdomen. Five years ago he had had a severe acute illness with fever, lasting two weeks. At the end of this time he was operated on for a "subphrenic abscess" on the left side. He was in the hospital for three months and was incapacitated for another month. There was no cough associated with this illness. Three years ago there first appeared a bulging in the region of the operative scar on the left chest. This has gradually increased in size. It has given no symptoms until about three weeks from the date of entrance, at which time, following a muscular strain during heavy work, it began to cause pain severe enough to make the patient seek relief.

The patient had been studied in the Washington University Dispensary and in the Chest Service of the Barnes Hospital by Doctors J. J. Singer and D. S. Allen and was sent into the hospital for surgical treatment.

Physical examination was negative except for the findings in the left chest. All the routine laboratory examinations gave negative results. In the posterior portion of the lower left axilla was an oblique linear operative scar about eight inches in length. A hernial mass about six inches in diameter was crossed by this scar. Palpation revealed a bone defect involving the eighth and ninth ribs for a distance of about six inches. This formed the border of the neck of the sac. The mass itself varied in consistency. At times gurgling of air could be felt, and at others, the sharp edge of a presumably solid organ. The patient was able to increase the size of the hernia by forced expiration with the mouth and nares closed. Physical examination of the chest and abdomen showed no abnormality. The level of the diaphragm showed no alteration. Fluoroscopic examination, after the introduction of lipiodol in the left lower lobe, showed the lung to be normal and not connected with the hernia. It was thought at first that the mass felt in the hernia might be a compressed lung.

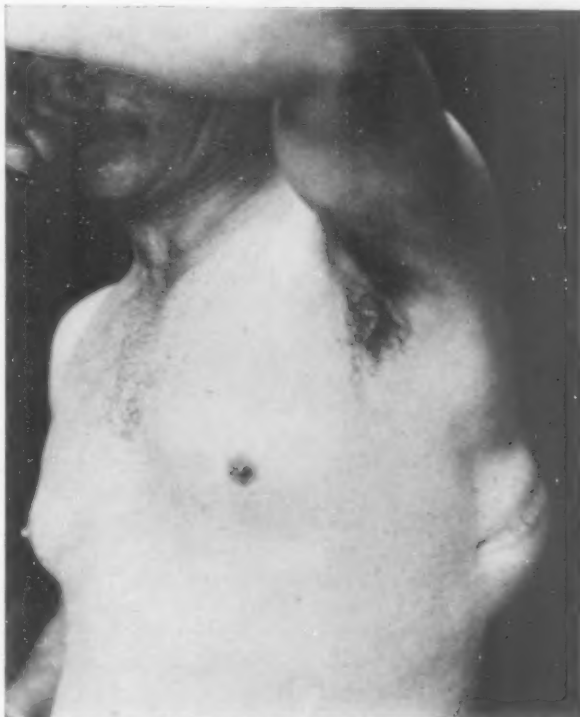


FIG. 1.—Photograph showing hernia and old operative scar. The patient is increasing intra-abdominal pressure by forced expiration with mouth and nares closed.

## BRIEF COMMUNICATION

Röntgen-ray plates included (a) plain plates (Fig. 2), (b) lipiodol outline of the bronchial tree (Fig. 3). The first showed a solid organ in the hernia. The second showed that the lung tissue apparently did not enter the hernia. It also showed an air-containing viscus in the hernia with an outline suggestive of colonic haustration. In none was an abnormal level of the diaphragm made out until compared with the post-operative plate. Negative pyelogram and gastro-intestinal contrast examinations were also made.

*Operation.*—July, 1926. General anaesthesia. The incision embraced the scar over the hernia. The skin was dissected back. The dissection was carried through the scar



FIG. 2.—Radiograph showing solid organ (spleen) in the hernia. Pre-operative. (The outer line indicates the outline of the skin, and the inner line, the outline of the spleen, as seen on the original film.)

until the bony margin of the ring was exposed and the peritoneum reached. This was stripped back from the upper margin of the ring until apparently normal fibres of the diaphragm attached to the seventh rib were exposed. In other words, the diaphragmatic attachment had been lifted at least four ribs. No defect in the diaphragm could be seen or felt. The pleural cavity was not entered. An attempt was then made to open the peritoneum. This was successful, after considerable difficulty, at the inner lower angle of the wound. It became obvious that the hernia was of a sliding type involving the attachment of both the splenic flexure and the thickened adherent spleen.

The free edge of the lower peritoneal fold was then imbricated under the upper fold and the latter tacked down over the former. Two incomplete layers of scar tissue could be dissected free at the upper margin of the bony ring. Interrupted

mattress sutures of chromic catgut were placed in the capsule of the spleen, and in the innermost of the two layers, and the spleen was thus firmly united to the upper margin of the ring, forming a tampon for the hernial opening. The upper and lower angles were not satisfactorily closed by this manœuvre. The union of the spleen to the bony ring was reinforced by the second of the two layers, which was sutured across the opening.

The entire hernial orifice was then interlaced in every direction by sutures taken from the fascia lata using the Gallie technic. The weak angles were particularly strongly reinforced.

The muscle masses of the back were united by two layers of interrupted chromic catgut sutures. A continuous silk suture was used to close the skin.

### TRANSTHORACIC ABDOMINAL HERNIA

The result seemed to be a firm wall. Transplantation of a rib was considered and discarded on account of an apparently satisfactory result.

The post-operative course was smooth. The patient was discharged on the fifteenth post-operative day.

The patient has been seen from time to time. He has worked intermittently since discharge. He was last seen on January 25, 1927, six and one-half months after opera-



FIG. 3.—Radiograph showing lipiodol outline of bronchial tree, and air-containing organ (colon) in the hernia. Pre-operative.

tion. Examination showed firm closure of the hernial orifice except at the upper posterior angle where there was slight bulging over an area one and one-half inches in diameter on forced expiration. Radiograph at this item showed clearly the abnormal attachment of the diaphragm.

Although this may well be a unique case, yet the unusual nature of the hernia makes proof of this point difficult. It cannot be classified as a diaphragmatic hernia under the usual definition of the latter as a hernia *through* the diaphragm. Certainly search through recent literature on diaphragmatic



#### BRIEF COMMUNICATION

hernia reveals no similar case. It is obvious, therefore, that a difficulty of nomenclature exists. The term used—trans thoracic abdominal hernia—seems to describe the condition clearly.

The most interesting pathological observation is the transplantation of the thoracic attachment of the diaphragm upward from the eleventh rib to the seventh rib. The patient's name for the primary condition ("sub-phrenisches Abzess") was given with no hesitation or suggestive questioning. Certainly the absence of scar tissue among the diaphragmatic muscle fibres was striking.

From the diagnostic viewpoint, the use of lipiodol insufflation of the bronchial tree to demonstrate the absence of lung tissue in the hernia is of the greatest interest. This method of examination is being used more and more freely in this clinic and elsewhere. This perhaps is a unique application.

The case further illustrates the refinement in diagnostic possibilities in thoracic disease by employment of newer methods, particularly under the favorable conditions created by close medical and surgical coöperation.

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#### CHANGE OF EDITORIAL ADDRESS

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